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CHARLES F. MARVIN, Chief

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CONTENTS.

NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the Editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for the illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

CLEVELAND ABBE, jr., Editor.

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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Beginning August, 1915, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1915. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions, that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW, but collected and published by States at selected section centers.

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month designated on the title page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are specially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.

The Meteorological Service of Cuba.

The Meteorological Observatory of Belén College, Habana.

The Government Meteorological Office of Jamaica.

The Meteorological Service of the Azores.

The Meteorological Office, London.

The Danish Meteorological Institute.

The Physical Central Observatory, Petrograd.

The Philippine Weather Bureau.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but such publication is not to be construed as official approval of the views expressed.

SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING SEPTEMBER, 1916.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., Oct. 28, 1916.]

For a description of instrumental exposures and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, April, and May, 1916, **44**:2, 179–180, and 244, respectively.

The monthly means and departures from normal values given in Table 1 show that direct solar radiation intensities averaged above normal at all stations, the plus departures being most pronounced at Madison, Wis., and Lincoln, Nebr. At none of the stations did the maximum intensity for the month equal the highest recorded September intensity.

TABLE 1.—*Solar radiation intensities during September, 1916.*

Washington, D. C.

[Gram-calories per minute per square centimeter of normal surface.]

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Sept. 1		0.88	0.77	0.67	0.56	0.51	0.49	0.46		
3	1.42	1.33	1.24	1.16	1.09	1.03				
4			1.02	0.90						
5		1.15								
7	1.22									
8	1.12	1.07	0.97	0.87	0.78	0.70	0.62	0.54	0.49	
9	1.44	1.28	1.13	1.02	0.91					
10	1.39	1.28	1.18	1.09	1.01	0.93				
11			1.19	1.10						
13	1.35									
16	1.33	1.22	1.14	1.02	0.84	0.73				
18	1.24	1.06	0.91							
19	1.49	1.38	1.26	1.17	1.11	1.05	0.98	0.93	0.88	0.84
20		1.25	1.07	0.97	0.88	0.80	0.73	0.68	0.63	0.58
21		1.31	1.15	1.05	0.99	0.95				
22		1.06	0.95	0.86	0.77	0.69	0.61	0.55		
23		1.25								
24		1.15	1.01	0.87	0.74	0.65				
25		1.20	0.97	0.84	0.77	0.70				
27		1.21	1.07							
30		1.43	1.32	1.22	1.15	1.10	1.03	0.98	0.93	0.89
Monthly means	**1.33**	**1.21**	**1.08**	**0.99**	**0.89**	**0.82**	**0.74**	**0.69**	**0.73**	**0.77**
Departure from 8-year normal	**+0.02**	**+0.01**	**+0.01**	**+0.01**	**+0.01**	**+0.02**	**+0.05**	**+0.06**	**+0.06**	**+0.12**
P. M.										
Sept. 16		0.88	0.79	0.58	0.48	0.39	0.33	0.27		
19		1.38	1.26	1.15	1.06	0.98	0.92	0.86	0.80	0.75
20		1.20	1.10	1.03	0.93	0.87	0.81	0.76	0.71	0.67
21		1.36	1.25	1.14	1.04	0.97	0.91	0.85	0.79	0.71
22		1.10	0.88	0.71	0.64	0.58				
27		1.26	1.12							
30		1.37	1.26	1.17	1.08	1.00	0.94	0.88	0.83	0.78
Monthly means		**1.22**	**1.09**	**0.96**	**0.87**	**0.80**	**0.78**	**0.72**	**0.78**	**0.73**
Departure from 8-year normal		**+0.03**	**+0.03**	**+0.01**	**±0.00**	**+0.02**	**+0.05**	**−0.03**	**±0.00**	**±0.00**

TABLE 1.—*Solar radiation intensities during September, 1916*—Contd

Madison, Wis.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Sept. 2	1.23	1.17								
8		1.26	1.19	1.11	1.04	0.97	0.91			
14				0.99	0.92	0.89	0.79			
18		1.34								
19		1.27		1.06						
21		1.25	1.10	0.98	0.88	0.80	0.74			
29		1.39	1.31	1.24	1.17	1.11	1.04			
Monthly means	**(1.23)**	**1.28**	**1.20**	**1.08**	**1 00**	**0.94**	**0.87**			
Departure from 7-year normal	**+0.09**	**±0.00**	**+0.07**	**+0.05**	**+0.03**	**+0.02**	**+0.01**			
P. M.										
Sept. 8		1.30	1.19	1.12						
18		1.33								
19		1.27	1.17	1.05						
Monthly means		**1.30**	**(1.18)**	**(1.08)**						
Departure from 7-year normal		**+0.09**	**+0.09**	**+0.08**						

Lincoln, Nebr.

Date.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.										
Sept. 13		1.39	1.27	1.17	1.08					
16		1.41	1.30	1.19	1.10	1.01				
21		1.32	1.25	1.18	1.11	1.05	1.00	0.91		
23		1.43	1.24		1.02	0.93	0.84			
25		1.38			1.17		1.02			
30		1.40	1.29							
Monthly means		**1.39**	**1.27**	**1.18**	**1.10**	**1.00**	**0.95**	**(0.91)**		
Departure from 2-year normal		**+0.10**	**+0.12**	**+0.16**	**+0.12**	**+0.13**	**+0.19**	**+0.26**		
P. M.										
Sept. 8	1.41	1.26	1.17	1.10	1.01	0.92	0.83	0.75	0.70	0.65
13	1.47	1.36	1.25	1.16	1.07	0.99	0.92	0.85	0.79	
14		1.40	1.30	1.24	1.15	1.06	1.01	0.97	0.83	
15		1.41								
18		1.34								
19		1.25	1.16	1.07	1.00	0.92	0.84	0.78		
20		1.28	1.13							
21		1.32								
22		1.31	1.20	1.09	1.01	0.94	0.87	0.81	0.75	0.70
30		1.34	1.18	1.04						
Monthly means	**(1.44)**	**1.33**	**1.20**	**1.12**	**1.05**	**0.97**	**0.89**	**0.83**	**0.77**	**(0.68)**
Departure from 2-year normal	**+0.09**	**+0.03**	**+0.03**	**+0.04**	**+0.08**	**+0.05**	**+0.03**	**+0.06**	**+0.06**	**−0.02**

Santa Fe, N. Mex.

Date.	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.										
Sept. 2			1.26	1.19	1.12	1.06	0.99	0.93	0.89	0.86
7	1.47	1.37	1.26	1.23	1.18	1.11	1.06	1.03	1.01	
8		1.44	1.30			1.11	1.05	1.00	0.93	0.87
13	1.53	1.45	1.39	1.27	1.16	1.18	1.14	1.07		0.94
14	1.50		1.31	1.24	1.16		1.04	1.02	1.00	0.96
15					1.10	1.07	1.04	1.01	0.97	0.89
26				1.27	1.24	1.21	1.16	1.10	1.02	0.99
27	1.53	1.47	1.40	1.33	1.24	1.16	1.10	1.06	1.03	1.01
29		1.45	1.39	1.32	1.27	1.22	1.18	1.14	1.08	
Monthly means	**1.51**	**1.44**	**1.33**	**1.26**	**1.18**	**1.14**	**1.08**	**1.04**	**0.99**	**0.93**
Departure from 4-year normal	**−0.01**	**+0.02**	**+0.01**	**±0.00**	**±0.00**	**±0.00**	**+0.01**	**+0.01**	**+0.01**	**±0.00**
P. M.										
Sept. 12		1.46	1.36		1.20	1.15	1.10	1.04	1.00	0.97
13		1.44	1.33	1.25	1.18	1.11	1.05	1.00	0.95	0.91
Monthly means		**(1.45)**	**(1.34)**	**(1.25)**	**(1.19)**	**(1.14)**	**(1.08)**	**(1.02)**	**(0.98)**	**(0.94)**

Skylight polarization measurements made at Washington on 11 days, with the sun at zenith distance 60°, give a mean of 56 per cent, with a maximum of 65 per cent on the 19th. This latter is 7 per cent less than the highest September polarization measurement previously obtained at Washington.

TABLE 2.—*Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.
1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*
Sept. 1	16.20	14.60	Sept. 2	8.81	6.02	Sept. 8	10.97	18.59	Sept. 2	7.87	8.48
3	6.02	8.18	8	11.38	10.21	13	8.81	10.97	7	9.83	7.57
4	10.97	13.13	14	9.83	7.87	14	3.30	4.57	8	9.83	7.57
5	16.20	16.79	18	4.17	4.37	15	4.37	4.95	13	6.02	6.91
7	17.37	18.59	19	5.36	6.76	16	5.79	7.04	14	5.36	6.27
8	17.37	18.59	21	7.04	6.02	18	5.16	7.57	15	5.79	5.16
9	12.28	9.83	29	4.17	4.75	19	7.29	10.97	26	3.99	2.74
10	7.29	8.48				20	9.83	5.79	27	4.37	3.00
11	9.83	9.14				21	5.16	4.95	29	4.57	4.37
13	14.10	17.37				22	5.16	7.57			
16	8.48	9.14				23	5.36	8.48			
18	9.83	13.13				25	11.81	10.97			
19	5.79	7.29				30	3.30	4.75			
20	7.29	8.18									
21	8.81	10.20									
22	11.38	13.61									
23	12.68	7.87									
24	7.57	10.59									
25	8.48	10.59									
27	10.97	11.81									
30	5.16	6.50									

Table 3 shows an excess of radiation as compared with the September average, amounting to 8.1 per cent for Washington, 2.9 per cent for Madison, and 7.4 per cent for Lincoln.

TABLE 3.—*Daily totals and departures of solar and sky radiation during September, 1916.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
1916.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
Sept. 1	480	328	290	63	− 64	−152	63	− 64	−152
2	362	518	457	− 53	129	17	10	65	−135
3	580	423	443	167	37	6	177	102	−129
4	573	299	530	161	− 83	95	338	19	− 34
5	525	244	452	115	−135	20	453	−116	− 14
6	230	506	435	−178	131	5	275	15	− 9
7	321	329	354	− 85	− 42	− 73	190	− 27	− 82
8	408	504	532	4	136	107	194	109	25
9	554	482	426	152	118	4	346	227	29
10	533	119	301	133	−241	−119	479	− 14	− 90
11	402	413	127	4	57	−290	483	43	−380
12	377	180	427	− 18	−173	12	465	−130	−368
13	410	346	551	17	− 3	139	482	−133	−229
14	231	223	539	−160	−122	129	322	−255	−100
15	126	236	506	−263	−105	99	59	−360	− 1
16	498	201	494	112	−136	90	171	−496	89
17	459	466	544	75	132	142	246	−364	231
18	454	498	516	73	168	117	319	−196	348
19	542	489	468	163	163	72	482	− 33	420
20	499	444	482	123	121	88	605	88	508
Decade departure.				....	....	....	**126**	**102**	**598**
Sept. 21	542	378	505	168	59	114	773	147	622
22	474	301	498	103	− 14	110	876	133	732
23	358	430	483	− 10	119	97	866	252	829
24	374	447	382	8	139	− 1	874	391	828
25	397	355	423	34	51	43	908	442	871
26	414	200	139	54	−101	−238	962	341	633
27	473	119	422	116	−178	48	1,078	163	681
28	348	164	511	−6	−130	139	1,072	33	820
29	58	421	376	−293	130	7	779	163	827
30	504	423	448	156	135	82	935	298	909
Decade departure.				....	....	....	**330**	**210**	**311**
Excess or deficiency since first of year:									
Gr.-cal.				....	....	....	**−5,519**	**+3,003**	....
Per cent.				....	....	....	**− 5.1**	**+ 2.8**	....

SHADING EFFECT OF WIRE INSECT CAGES.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated Weather Bureau, October 26, 1916.]

In the departmental experiments designed to discover methods for protecting plants from insect enemies some plants are wholly inclosed by a "cage" or framework covered with wire window screening. Such a screen of course intercepts a certain amount of the solar energy otherwise supplied to the plant, and it was desired to determine this screening effect as exactly as possible, since the screen must be left over the plant for a considerable period of its growth in order to give effective protection against insects.

The tests here described were made with a wire insect cage submitted by Dr. B. R. Coad, Bureau of Entomology, United States Department of Agriculture, in charge Delta Laboratory, Tallulah, La. The cage is made of 16-mesh wire cloth, the diameter of the wire measuring 0.011 + in. It is therefore presumed to be No. 29 wire, American gage, with a diameter of 0.011257 in. The wires of the woof are straight. Those of the warp are bent in crossing the woof, at an angle whose sine is $225.14/625 = 0.3602$, or 21° 7′. The wires of the warp run vertically in the sides of the cage, and if the side containing the door is on the north side they run north and south in the top of the cage.

In measuring the transmission of the wire cloth a Smithsonian silver disk pyrheliometer was read inside the cage, while at the same time the total radiation was measured by means of a Marvin pyrheliometer exposed near by. At intervals the two instruments were compared by exposing both to the total solar radiation, and the results are summarized in Table 1.

TABLE 1.—*Summary of comparisons of Marvin and Smithsonian pyrheliometers.*

[Radiation in gram-calories per min., per sq. cm.]

Date and time. (75th mer.)	Number of readings.	Radiation.		Ratio:
		Marvin.	Smithsonian.	Smithsonian / Marvin.
1916.		*Gr.-cal.*	*Gr.-cal.*	
Aug. 14, 10:35 a. m.	7	1.389	1.405	1.012
14, 1:45 p. m.	7	1.377	1.369	0.994
18, 11:05 a. m.	9	1.051	1.076	1.022
22, 11:06 a. m.	9	1.160	1.178	1.016

In the first transmission tests made the top or a side of the cage was kept normal to the incident solar rays, this adjustment being maintained by watching the shadow cast by the frame. When thus adjusted the bent wires of the warp cast no more shadow than the straight wires of the woof.

The entire area of a unit square of the wire cloth, which is comprised between the axes of the bounding wires, equals $(0.0625 \text{ in.})^2$, or 0.003906 sq. in. The area of the clear space which transmits radiation equals $(0.0625 \text{ in.} - 0.011257 \text{ in.})^2$, or 0.002626 sq. in. The proportional part of the radiation transmitted should therefore be $2626/3906 = 0.672$, and the part cut off by shading $= 0.328$. The measurements summarized in Table 2 give a somewhat greater shading effect than the above.

TABLE 2.—*Determinations of the transmission coefficent,* a, *of wire screen when normal to the incident solar rays.*

[Radiation in gram-calories per min., per sq. cm.]

Date and time. (75th mer.)	Number of readings.	Radiation.		Transmission, a	Shading effect.	Remarks.
		Total.	In cage.			
1916.		*Gr.-cal.*	*Gr.-cal.*			
Aug. 14, 11:13 a. m.....	9	1.422	0.941	0.662	0.338	Through top of cage.
14, 1:16 p. m....	11	1.381	0.928	0.672	0.328	Do.
14, 4:30 p. m....	9	1.196	0.778	0.652	0.348	Through side of cage.
17, 11:41 a. m....	9	1.130	0.757	0.670	0.330	Through top of cage.
22, 12:59 p. m....	8	1.145	0.762	0.666	0.334	Do.
Means.................	....	....	....	**0.664**	**0.336**	

The receiving surface of the pyrheliometer is always normal to the incident solar rays. The angle of incidence with the wires of the warp and of the woof may be any angle from 0° (normal incidence) to 90°. In studying the shading effect of the wires with the incident angle other than 0° we will for convenience consider a unit mesh of the cloth to consist of the clear space 0.051243 in. square, bounded on one side by a wire of the warp and on an adjacent side by a wire of the woof, the wires overlapping at a corner. The relative lengths of the projections upon the pyrheliometric surface of these three sections of wire—warp, woof, and a corner—if the plane of the cloth is normal to the incident rays, are 0.450, 0.450, and 0.100, respectively. Let the angle of incidence of the solar rays with wires of the woof be 0°, and at right angles to these wires let the angle of incidence with the plane of the cloth be i. An increased number of individual squares of the mesh will now be projected upon the pyrheliometric surface, but their projected area will be the same as before. The projected number of wires of the warp, their length, and in consequence their projected area, remain unchanged. In the case of the wires of the woof, however, while their projected length is unchanged, their number has increased in the proportion $1/\cos i$. Therefore, the area of shadow now cast by the three sections of wire may be expressed by the equation

$$S = 0.450/\cos i + 0.450 + 0.100 \qquad (1)$$

where S is the area of shadow cast by the wires as compared to the area when the wire cloth is normal to the incident rays.

In Table 3 are summarized measurements made under the conditions described above. It is to be noted that the average value of $(100-a)/S$ is practically what would be expected from the size of the wire and the mesh of the cloth.

Assuming that the solar rays are parallel rays, complete shading by the wires of the woof will occur when cosine $i = 112.57/625 = 0.1801$. Substituting in equation (1) we obtain $0.450/0.1801 + 0.55 = 3.05$. Also, $1.000/0.328 = 3.05$; or, the area shaded when the wire cloth is normal to the incident rays must be increased 3.05 times for complete shading.

The angle i has been determined from h, the computed altitude of the sun at the time of the measurements, the top of the screen having been kept horizontal by means of a spirit level. With the top horizontal it has been assumed that the sides are vertical. With the sun shining through the top of the cage, $i = 90° - h$; when shining through a side, $i = h$.

TABLE 3.—*Determinations of the transmission coefficient,* a, *of wire screen with the wires of the woof at normal incidence, and at right angles to these wires the angle of incidence with the plane of the cloth=i.*

[Radiation in gram-calories per min., per sq. cm.]

Date and time.	No. of readings.	Radiation.		Transmission, a	i		S	$\frac{100-a}{S}$	Remarks.
		Total.	In cage.						
1916. Aug. 14:		*Gr.-cal.*	*Gr.-cal.*		°	′			
11:42 a. m....	11	1.417	0.928	0.654	25	28	1.05	0.329	Through horizontal top of cage.
3:28 p. m....	9	1.311	0.763	0.582	49	22	1.24	0.337	Do.
Aug. 17:									
10:41 a. m....	9	1.042	0.691	0.663	32	48	1.09	0.310	Do.[b]
11:11 a. m....	9	1.108	0.746	0.673	29	04	1.06	0.307	Do.[c]
1916. Aug. 18:									
10:01 a. m....	7	1.041	0.642	0.617	39	13	1.13	0.338	Do.[b]
10:28 a. m....	9	1.051	0.702	0.668	34	44	1.10	0.302	Do.[c]
Aug. 22:									
1:25 p. m....	9	1.115	0.737	0.662	31	50	1.08	0.313	Do.
Mean.....	......	......	......	......	......		......	**0.319**	
Aug. 14:									
9:55 a. m....	7	1.353	0.771	0.574	51	02	1.27	0.336	Through vertical side of cage.
10:11 a. m....	5	1.372	0.756	0.551	53	42	1.31	0.343	Do.
4:01 p. m....	9	1.258	0.820	0.652	34	23	1.10	0.318	Do.
Aug. 17:									
9:52 a. m....	7	0.989	0.568	0.574	49	41	1.25	0.342	Do.
Aug. 18:									
9:24 a. m....	1	1.008	0.602	0.596	44	50	1.19	0.339	Do.
9:26 a. m....	1	1.022	0.616	0.604	45	16	1.19	0.333	Do.
9:28 a. m....	1	1.021	0.609	0.597	45	36	1.19	0.339	Do.
9:30 a. m....	1	1.013	0.607	0.601	45	58	1.20	0.332	Do.
9:32 a. m....	1	1.017	0.600	0.588	46	20	1.20	0.343	Do.
9:34 a. m....	1	1.024	0.620	0.608	46	42	1.21	0.324	Do.
9:36 a. m....	1	1.028	0.629	0.611	47	03	1.21	0.321	Do.
9:38 a. m....	1	1.028	0.620	0.602	47	24	1.22	0.326	Do.
9:40 a. m....	1	1.021	0.602	0.590	47	51	1.22	0.336	Do.
Mean...	......	......	......	......	......		......	**0.333**	
Aug. 22:									
11:26 a. m....	1	1.172	0.580	0.496	61	04	1.48	0.341	Do.
11:28 a. m....	1	1.185	0.587	0.495	61	14	1.49	0.339	Do.
11:30 a. m....	1	1.170	0.584	0.499	61	22	1.49	0.336	Do.
11:32 a. m....	1	1.191	0.577	0.485	61	30	1.49	0.346	Do.
11:34 a. m....	1	1.180	0.562	0.476	61	38	1.50	0.349	Do.
11:36 a. m....	1	1.144	0.554	0.486	61	46	1.50	0.341	Do.
11:38 a. m....	1	1.155	0.553	0.479	61	54	1.51	0.345	Do.
11:40 a. m....	1	1.158	0.553	0.477	62	00	1.51	0.346	Do.
11:42 a. m....	1	1.179	0.547	0.464	62	09	1.51	0.355	Do.
Mean.....	......	......	......	......	......		......	**0.344**	
Weighted mean.......	......	......	......	......	......		......	**0.327**	

[b] Pyrheliometer outside door of cage, at distance from screen.
[c] Pyrheliometer on high box close to screen.

Let the angle between the horizontal projection of a solar ray and a wire of the woof be called θ. Also, project the solar ray upon two planes perpendicular to the plane of the cloth and to each other, one of which contains a wire of the woof and the other is perpendicular to these wires; and designate by α and i, respectively, the angles between these projections and a line vertical to the plane of the cloth. Further let L = the length of a section of the warp between intersecting corners, and p = its projection upon the pyrheliometric surface. Expressed in terms of the length of a section of the woof between these intersecting corners,

$$L = \frac{1}{\cos(\sin^{-1} 0.3602)} \qquad (2)$$

and

$$p = \frac{1/2 \cos(i + \sin^{-1} 0.3602) + 1/2 \cos(i - \sin^{-1} 0.3602)}{\cos(\sin^{-1} 0.3602)\cos(\sin^{-1} 0.3602 \sin\alpha)}$$

$$= \frac{\cos i}{\cos(\sin^{-1} 0.3602 \sin\alpha)}. \qquad (3)$$

The equation for S now becomes

$$S=\frac{0.450}{\text{os}\ i}+\frac{0.100}{\cos i}+\frac{p\,(0.550-0.100/\cos i)}{\cos i\,\cos\alpha} \qquad (4)$$

In the above equation, for transmission through the horizontal top of the cage

$$\sin i=\frac{\cos h \sin\theta}{\sqrt{1-\cos^2 h\ \cos^2\theta}} \qquad (5)$$

and

$$\sin\alpha=\frac{\cos h \cos\theta}{\sqrt{1-\cos^2 h \sin^2\theta}} \qquad (6)$$

For transmission through a vertical side of the cage,

$$\cos i=\cos h\sin\theta, \qquad (7)$$

and

$$\cos\alpha=\sin\theta. \qquad (8)$$

For computing the shading effect of a vertical side of the screen equation (4) may be expanded to

$$S=\frac{0.45}{\cos h\sin\theta}+\frac{0.100}{\cos h\sin\theta}+\frac{0.550-0.100/\cos h\sin\theta}{\sin\theta\cos\,(\sin^{-1}0.3602\,\cos\theta)}. \qquad (9)$$

The expanded equation for computing the shading effect of the horizontal top of the screen becomes very complicated. For all practical purposes, however, we may employ the equation

$$S=\frac{0.450}{\sin h}+0.550+C, \qquad (10)$$

where C is a correction to be applied for the effect of the bend in the wires of the warp. It is negligible for small values of the angle α, is about 1 per cent for $\alpha=45°$, 2 per cent for $\alpha=60°$, and for larger values of α will rarely exceed 3 per cent.

In Table 4 are summarized measurements made through the horizontal top or a vertical side of the cage, and reduced by equations (9) and (10). The angle θ has been obtained by measuring the angle between the side of the cage and the edge of the shadow cast on the ground by an upright corner. Some irregularities appear in the results, partly due no doubt to lack of accuracy in the determinations of θ and h, and partly to the fact that the wire cloth is not stretched perfectly flat on the frames. It is to be noted, however, that the weighted mean of $(100-a)/S$ differs by less than 1 per cent from the mean of the results given in Tables 2 and 3.

The mean value of $(100-a)/S$ as derived from Tables 2, 3, and 4, is 0.332. This value indicates a diameter of the wire of 0.01139 inch instead of 0.011257 inch, an increase that may easily have been brought about by oxidation. Apparently there is little reflection from the wires to the pyrheliometric surface.

The angle α that produces complete shading by the wires of the warp is not so easily determined as the angle i that produces complete shading by the wires of the woof, on account of the bend in the former. With the cloth horizontal, and $\theta=0°$, every other row of overlapping corners will come together so as to produce a line of complete shading on a wire of the woof when $h=29°\ 35'$. Complete shading between the four wires of the warp thus meeting will have extended to their centers when $h=10°\ 23'$, and complete shading of the pyrheliometric surface will have been accomplished when $h=5°\ 10'$. With $\theta=45°$ the shading becomes complete when $h=7°\ 19'$.

TABLE 4.—*Determination of the transmission coefficient,* **a**, *of wire screen when exposed in a horizontal or vertical plane.*

[Radiation in gram-calories per min., per sq. cm.]

Date and time (75th Mer.).	No. of readings.	Radiation. Total.	Radiation. In cage.	Transmission coefficient, a.	h	θ	S	$\frac{100-a}{S}$	Remarks.
1916.		*Gr.-cal.*	*Gr.-cal.*		° ′	° ′			
Aug. 14:									
2:23 p. m..	9	1.360	0.872	0.642	52 12	25 40	1.13	0.317	Thru hor. top.
Aug. 22:									
10:12 a. m..	8	1.099	0.704	0.640	52 12	34 30	1.13	0.319	Do.
Aug. 14:									
2:53 p. m..	9	1.340	0.415	0.310	47 02	30 00	2.15	0.321	Thru vert. side.
Aug. 22:									
9:43 a. m..	9	1.100	0.203	0.184	47 32	26 14	2.36	0.345	Do.
10:39 a. m..	9	1.142	0.379	0.332	56 05	44 20	1.85	0.361	Do.
Sept. 21:									
4:08 p. m..	9	1.101	0.671	0.610	21 58	51 45	1.30	0.301	Do.
9:30 a. m..	1	1.292	0.397	0.308	38 27	31 00	1.98	0.349	Do.
9:32 a. m..	1	1.284	0.400	0.312	38 50	31 30	1.96	0.351	Do.
9:34 a. m..	1	1.273	0.403	0.317	39 08	32 00	1.94	0.352	Do.
9:36 a. m..	1	1.278	0.416	0.325	39 25	32 30	1.93	0.350	Do.
9:38 a. m..	1	1.285	0.420	0.327	39 44	33 00	1.91	0.352	Do.
9:40 a. m..	1	1.306	0.432	0.330	40 02	33 30	1.90	0.353	Do.
9:42 a. m..	1	1.299	0.438	0.337	40 20	34 00	1.88	0.353	Do.
9:44 a. m..	1	1.289	0.444	0.344	40 38	34 30	1.87	0.351	Do.
9:46 a. m..	1	1.298	0.453	0.348	40 56	35 00	1.85	0.352	Do.
9:48 a. m..	1	1.303	0.464	0.357	41 14	35 30	1.84	0.349	Do.
9.50 a. m..	1	1.304	0.468	0.360	41 35	36 00	1.82	0.352	Do.
Mean..								*0.351*	
1:42 p. m..	1	1.382	0.323	0.234	45 19	28 00	2.22	0.345	Do.
1:44 p. m..	1	1.379	0.312	0.226	44 59	27 23	2.25	0.344	Do.
1:46 p. m..	1	1.372	0.284	0.207	44 44	26 46	2.28	0.346	Do.
1.48 p. m..	1	1.362	0.271	0.199	44 28	26 09	2.31	0.347	Do.
1:50 p. m..	1	1.360	0.251	0.185	44 14	25 32	2.34	0.348	Do.
1:52 p. m..	1	1.361	0.235	0.173	43 58	24 55	2.37	0.349	Do.
1:54 p. m..	1	1.352	0.212	0.157	43 44	24 18	2.40	0.351	Do.
1:56 p. m..	1	1.359	0.209	0.154	43 28	23 41	2.43	0.348	Do.
1:58 p. m..	1	1.356	0.200	0.147	43 14	23 04	2.46	0.347	Do.
2:00 p. m..	1	1.365	0.185	0.136	42 58	22 26	2.50	0.346	Do.
2:02 p. m..	1	1.376	0.172	0.125	42 43	21 48	2.54	0.344	Do.
2:04 p. m..	1	1.377	0.157	0.114	42 26	21 10	2.58	0.343	Do.
2:06 p. m..	1	1.381	0.138	0.100	42 10	20 32	2.62	0.344	Do.
2.08 p. m..	1	1.374	0.120	0.088	41 54	19 54	2.66	0.343	Do.
2:10 p. m..	1	1.371	0.101	0.074	41 38	19 16	2.70	0.343	Do.
2:12 p. m..	1	1.358	0.088	0.065	41 22	18 38	2.74	0.341	Do.
2:14 p. m..	1	1.351	0.070	0.052	41 02	18 00	2.78	0.341	Do.
Mean..								*0.345*	
Weighted mean.								**0.334**	

In the customary use of the cage it is necessary to consider not only the transmission of direct solar radiation, as it has been determined above, but also the transmission of diffuse sky radiation. If the latter has the same angle of incidence as the former the transmission coefficient for the two should not differ. But we must consider the angle of incidence for sky radiation as a weighted mean of all possible angles, small angles having the greater weight. This mean may be either greater or less than the angle of incidence for solar radiation, and, unlike the latter, it will vary but little throughout the day.

Furthermore, while the radiation reflected from the small section of wire cloth to which the Smithsonian pyrheliometric surface is exposed may be inappreciable in amount, the reflection from the entire interior surface of the cage may be a measurable quantity.

The proportion of the total solar and sky radiation received at different points within a wire cage has been determined by alternately exposing a Callendar recording pyrheliometer inside and outside the cage.[1] This pyr-

[1] The pyrheliometer is described in this REVIEW for August, 1914, 42: 474–480; and the factors by which its records may be reduced to heat units are given in this REVIEW for January, 1916; 44: 4.

heliometer has its receiving surface exposed horizontally to the whole hemispherical vault of the sky. The top of the wire cage has also been kept horizontal. Figures 1, 2, and 3 are reproductions of records obtained, the solid portions of the traces indicating actual record, and the dotted portions the record supplied by interpolation. The upper curve is the record of the total radiation. The intermediate curve represents the radiation recorded inside the cage.

In Table 5 are computations by equations (9) and (10) of the value of S, from data obtained in connection with the originals of the above curves. The "radiation record" gives the distance in tenths of inches from the zero line on the record sheet to the respective traces at the times specified, a tenth of an inch being the distance between the horizontally ruled lines on the record sheets. In figures 1 to 3 every fifth line only is drawn in full, the spacing for the remaining lines being shown on the right and left margins.

The method of determining h and θ has already been described.

It is to be noted that the values of $(100-a)/S$ are systematically lower than in Tables 3 and 4. We may compute the intensity of radiation inside the cage, that would have given for $(100-a)/S$ the value 0.332, from the equation

$$\text{Radiation in cage} = (100 - 0.332S) \times \text{total radiation.} \qquad (11)$$

TABLE 5.—*Determination of the transmission coefficient, a, of wire screen for solar and sky radiation.*

Date and time. (75th mer.)	Radiation record. Total.	Radiation record. In cage.	Transmission, a	h	θ	S	$\frac{100-a}{S}$	D	Remarks.
1916. Aug. 25:	$\frac{1}{10}$-in.	$\frac{1}{10}$-in.		° ′	° ′				
9:30 a. m.	31.0	9.8	0.316	46 18	28 00	2.24	0.305	2.0	Sun through south side.
10:00 a. m.	34.3	13.5	0.394	51 10	34 10	2.06	0.294	2.9	Do.
10:30 a. m.	37.5	16.5	0.440	55 19	41 40	1.90	0.295	2.9	Do.
11:00 a. m.	39.9	19.2	0.481	58 47	54 00	1.71	0.304	2.2	Do.
11:30 a. m.	41.3	21.2	0.513	60 57	72 00	1.55	0.314	1.3	Do.
NOON	42.0	22.5	0.536	61 49	90 00	1.50	0.309	1.6	Do.
12:30 p. m.	41.3	22.5	0.545	60 57	75 00	1.52	0.299	2.2	Do.
1:00 p. m.	40.4	22.1	0.547	58 47	64 30	1.56	0.290	2.8	Do.
1:30 p. m.	39.5	20.6	0.522	55 19	53 30	1.62	0.295	2.6	Do.
2:00 p. m.	38.2	18.2	0.476	51 10	42 00	1.79	0.293	2.9	Do.
2:30 p. m.	35.1	15.1	0.430	46 18	32 30	2.03	0.281	3.9	Do.
3:00 p. m.	31.1	11.9	0.383	41 06	27 40	2.17	0.284	3.4	Do.
3:30 p. m.	26.5	9.0	0.340	35 36	21 10	2.49	0.265	4.6	Do.
Sept. 19:									
9:30 a. m.	35.3	22.5	0.637	39 13	54 10	1.37	0.265	3.4	Sun through east side.
10:00 a. m.	41.0	23.2	0.566	43 34	46 15	1.56	0.279	3.6	Do.
10:30 a. m.	44.4	21.0	0.473	47 12	36 00	1.90	0.277	4.7	Do.
11:00 a. m.	46.6	13.0	0.279	50 05	24 00	2.54	0.284	6.1	Do.
1:00 p. m.	44.5	9.0	0.202	50 05	21 00	2.73	0.290	5.2	Sun through west side.
1:30 p. m.	41.2	18.6	0.451	47 12	30 45	2.12	0.259	6.7	Do.
2:00 p. m.	37.4	21.1	0.564	43 34	40 25	1.71	0.255	5.1	Do.
2:30 p. m.	33.8	20.7	0.612	39 13	49 20	1.45	0.268	3.3	Do.
3:00 p. m.	29.7	18.6	0.628	34 26	55 30	1.31	0.284	1.9	Do.
3:30 p. m.	24.7	16.2	0.656	29 20	62 00	1.20	0.287	1.4	Do.
4:00 p. m.	19.5	13.3	0.682	23 52	68 30	1.12	0.284	1.1	Do.
4:30 p. m.	13.4	8.6	0.642	18 16	75 00	1.06	0.338	0.0	Do.
Sept. 20:									
9:30 a. m.	29.9	18.2	0.619	38 56	35 46	1.28	0.298	1.1	Sun through top.
10:00 a. m.	35.1	21.1	0.601	43 16	43 55	1.22	0.327	0.4	Do.
11:00 a. m.	41.7	26.3	0.631	49 44	64 00	1.14	0.324	0.5	Do.
NOON	43.4	28.7	0.661	52 09	88 00	1.12	0.303	1.6	Do.
1:00 p. m.	41.0	26.0	0.634	49 44	68 45	1.14	0.321	0.7	Do.
2:00 p. m.	34.0	21.8	0.641	43 16	49 00	1.21	0.297	1.6	Do.
3:00 p. m.	27.8	17.0	0.612	34 10	32 00	1.37	0.283	2.0	Do.
4:00 p. m.	18.2	9.8	0.539	23 38	22 30	1.69	0.273	1.9	Do.
4:30 p. m.	15.0	6.1	0.407	18 02	17 00	2.03	0.292	1.3	Do.

In the last column of Table 5 is given the difference, D, between the radiation measured in the cage, or the observed radiation, and that computed by means of equation (11). It will be noticed that the difference is at a maximum when the incident angle for direct solar radiation is large.

On September 19, a record of the total sky radiation was obtained at 1:10 p. m. (E, fig. 2). It shows almost exactly the same intensity as that measured at 12:45 p. m. inside the cage, when the pyrheliometer was completely shaded from the sun by the wooden frame of the cage. Since, as will be apparent later from equation (12), we can not suppose that the transmission of sky radiation averages much over 0.5, nearly one-half the radiation measured at 12:45 p. m., or about two spaces on the record sheet, must represent radiation reflected from the wire cloth. The differences in the last column of Table 5 would lead us to expect a value of this order for the reflected radiation.

The measurements summarized in Table 5, and also other measurements not here given, indicate that for the total solar and sky radiation the shading effect is not $0.332S$, as for direct solar radiation, but that it varies between $0.320S$ and $0.270S$, the higher value corresponding to small values of the angle of incidence for solar rays, and the lower value to large incident angles. Probably $0.300S$ is an average value.

In the cage with which these tests were made the wooden frame consists of $2\frac{1}{2}'' \times 1\frac{1}{2}''$ sticks, with a $\frac{1}{2}''$ strip nailed on the outside to secure the wire cloth. Across the center of the top and parallel with the wires of the warp is a $1\frac{1}{2}'' \times 1\frac{1}{2}''$ stick.

For normal incidence of the solar rays with the top of the cage, and considering the rays parallel, the frame shades 15 per cent of the 48-inch cube inclosed by the wire cloth. For normal incidence with the east or west side the shading is 16 per cent, and for normal incidence with the south side it is 20 per cent. With the angles h and θ each equal to 45°, the shading is 18 per cent. The shading by the north side is considerably in excess of the shading by the other sides, on account of the frame of the door it contains. Since, however, this side transmits very little direct solar radiation, it is of relatively small importance, and we shall not be greatly in error if we assume 18 per cent for the average shading by the wooden frame of the cage. The average total shading effect of the wire cage for solar and sky radiation, or S', may therefore be approximately expressed by the equation

$$S' = 0.18 + 0.82 \times 0.300S = 0.18 + 0.246S. \qquad (12)$$

Still another approximation to the shading effect of the wire cage may be derived from the values of a in Table 5, mean values of which for different hour angles of the sun from the meridian are given in Table 6.

TABLE 6.—*Transmission of wire screen for solar and sky radiation.*

Sun's hour angle from the meridian.	Side of cage through which the sun is shining. East or west.	South.	Top.
	a.	a.	a.
6–5	0.68	....	....
5–4	0.67	....	0.41
4–3	0.65	0.34	0.58
3–2	0.60	0.37	0.61
2–1	0.45	0.48	0.63
1–0	0.10	0.56	0.65

At midday the altitude of the sun above the horizon is $90° - \phi + \delta$, where ϕ is the latitude of the place and δ is the solar declination.

South of latitude 40° N. the solar altitude at noon will exceed 50°, from the vernal to the autumnal equinox, and more than half of the space within the screened inclosure will therefore receive solar radiation through the top of

CURVES OBTAINED BY CALLENDAR RECORDING PYRHELIOMETER.

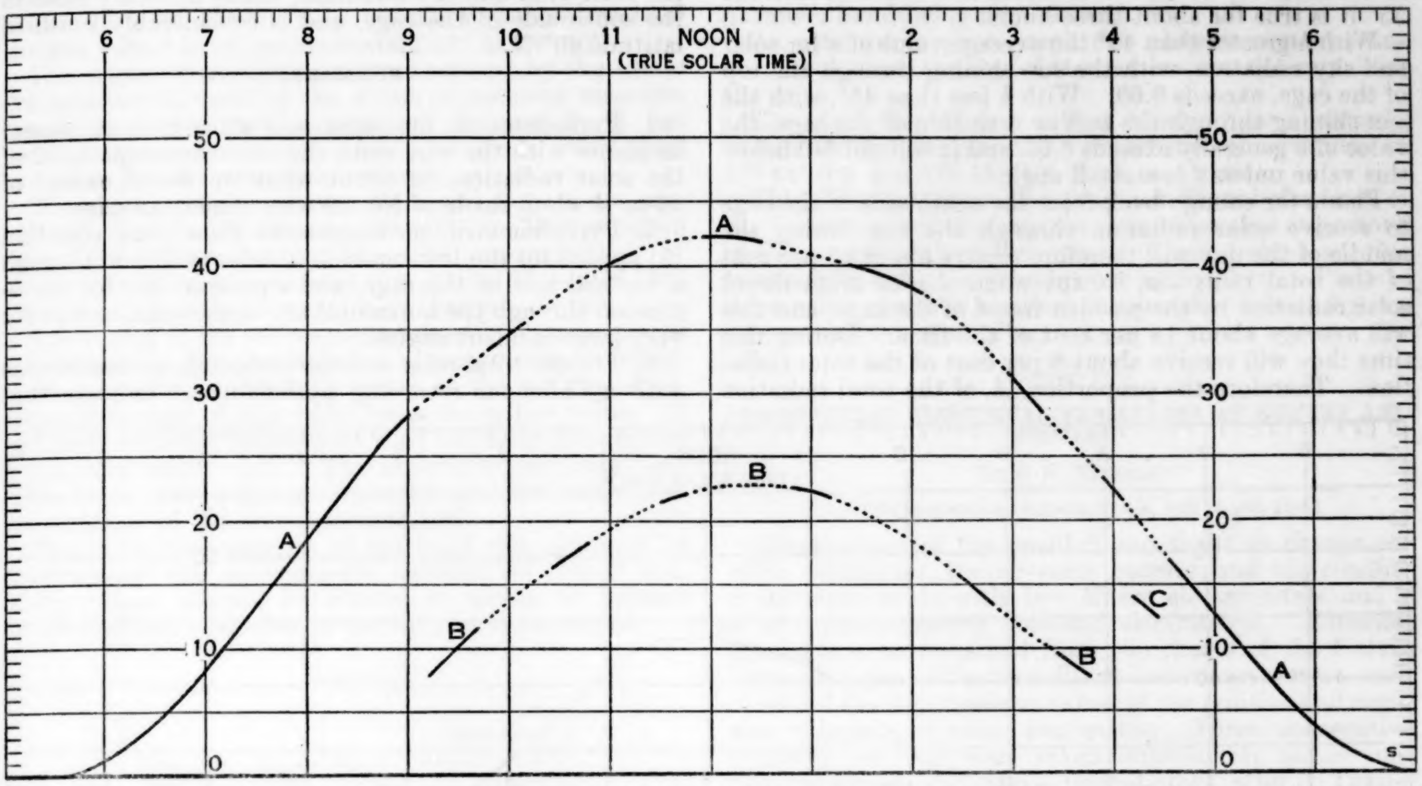

FIG. 1.—Wire insect cage transmission tests, August 25, 1916. Upper curve, *A A*, total solar and sky radiation, measured outside the cage. Intermediate curves, radiation measured inside the cage: *B B*, with sun shining through south side; *C*, with sun shining through the west side.

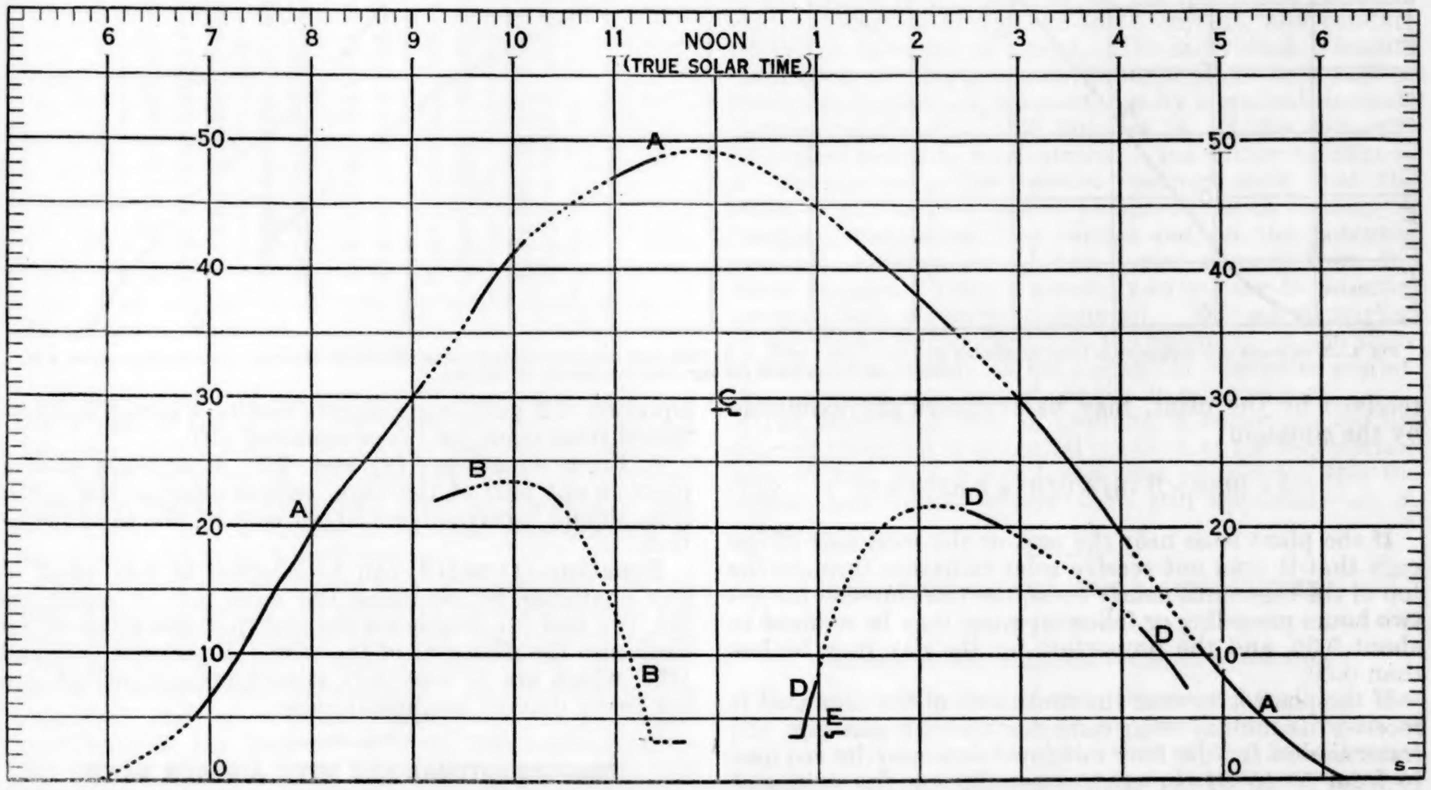

FIG. 2.—Wire insect cage transmission tests, September 19, 1916. Upper curve, *A A*, total solar and sky radiation, measured outside the cage. Intermediate curves, radiation measured inside the cage: *B B*, with sun shining through east side; *C*, with sun shining through south side; *D D*, with sun shining through west side. *E*, total sky radiation, measured outside the cage.

the cage. During most of this period this is true for two hours each side of true solar noon, and south of latitude 35° it is true for about three hours.

With h greater than 45° the average value of a for solar and sky radiation, with the sun shining through the top of the cage, exceeds 0.60. With h less than 45°, with the sun shining through the east or west side of the cage, the value of a generally exceeds 0.60, and it will not fall below this value unless θ is a small angle.

Plants far enough back from the south side of the cage to receive solar radiation through the top during the middle of the day will therefore receive about 65 per cent of the total radiation, except when shaded from direct solar radiation by the wooden frame of the cage, and this will average about 18 per cent of the time. During this time they will receive about 8 per cent of the total radiation. Therefore the proportion, A, of the total radiation received by the plant, may be expressed approximately by the equation

$$A = (0.08 \times 0.18) + (0.65 \times 0.82) = 0.55 \qquad (13)$$

If the plant is so near the east or the west side of the cage that it does not receive solar radiation through the top of the cage until nearly noon, the transmission for the two hours preceding or following noon may be reduced to about 0.30, and the proportion for the day may be less than 0.50.

If the plant is so near the south side of the cage that it receives its midday solar radiation through this side, the transmission for the four midday hours may be reduced to from 50 to 30 per cent, depending on the values of h and θ.

The lower the latitude the less will be the amount of radiation transmitted through the south side of the screen, and, likewise, the smaller will be the area receiving radiation through this side. Therefore, a plant in any part of the cage should receive on an average at least one-half the total solar and sky radiation, unless it is very close to the south side of the cage, and is considerably south of latitude 40° N.

SUMMARY.

1. Pyrheliometric measurements show that at normal incidence with the wire cloth the wires intercept 0.332 of the solar radiation, or about what we would expect of 16-mesh cloth made of No. 29 wire, American gage.

2. Pyrheliometric measurements show that equation (9) applies for the transmission of solar radiation through a vertical side of the cage, and equation (10) for transmission through the horizontal top of the cage, except for very large incident angles.

3. For the total solar and sky radiation, measurements with a Callendar recording pyrheliometer indicate that equation (12) gives approximate results, where S is determined from equation (9) or equation (10).

4. From equations (12) and (13), it appears that a plant in any part of the cage, except close to the south side, should receive about 50 per cent of the total radiation.

Equations (1) to (10) can be adapted to wire cloth of any character by changing the constants in equations (1), (2), and (4), which are derived from the mesh of the cloth and the diameter of the wire. Equations (12) and (13), which are at best only approximately correct, are not easily derived mathematically.

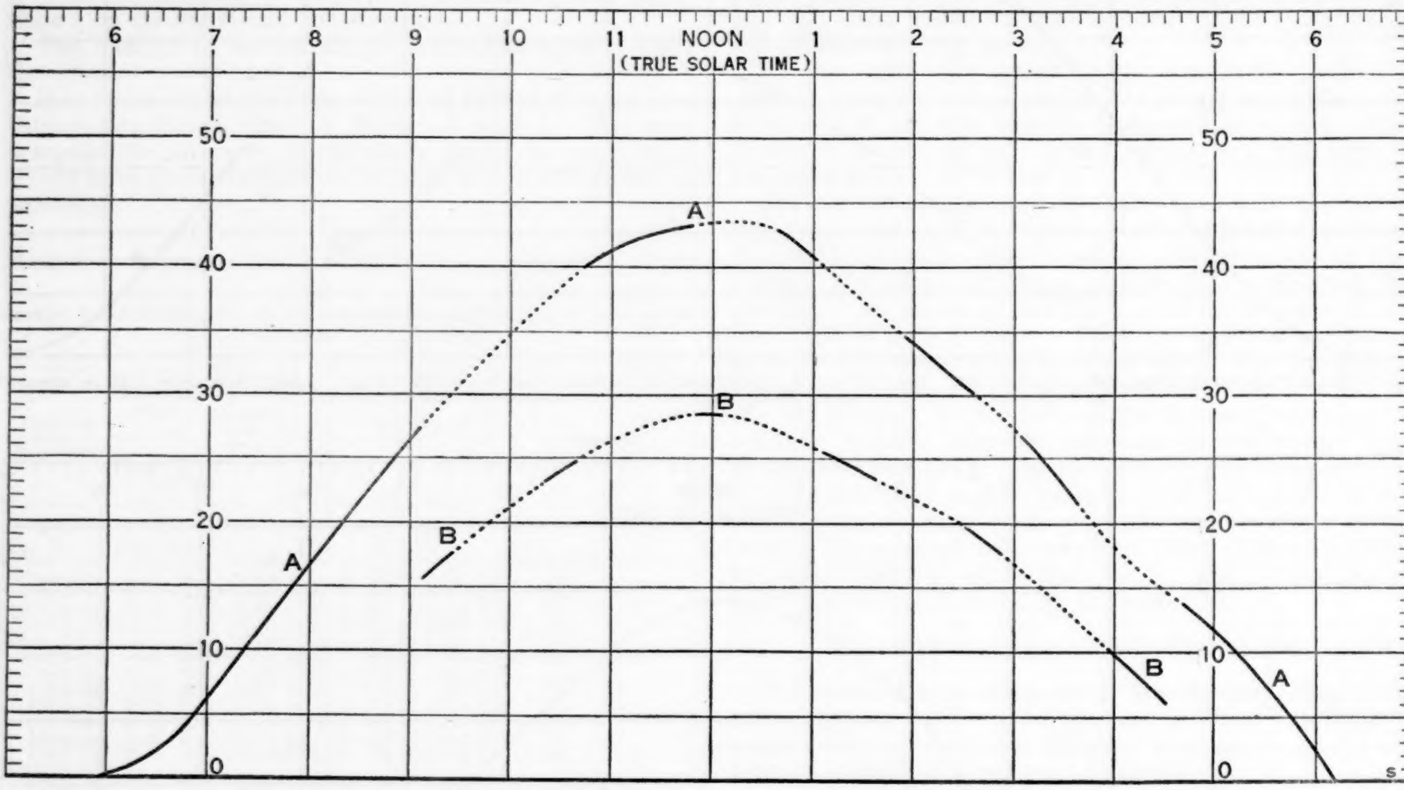

FIG. 3.—Wire insect cage transmission tests, September 20, 1916. Upper curve, A A, total solar and sky radiation, measured outside the cage. Intermediate curve, B B, radiation measured inside the cage, with sun shining through top.

CIRCUMZENITHAL ARC WITH A BLACK BAND.

By HOWARD H. MARTIN, Assistant Observer.

[Dated: Fort Worth, Tex., Aug. 12, 1916.]

An exceptional opportunity to make accurate observations of the circumzenithal arc was afforded the writer on the afternoon of August 6, 1916. The phenomenon was

observed from $18^h\ 34^m$ to $19^h\ 06^m$, 75th meridian time ($17^h\ 34^m$ and $18^h\ 06^m$, resp., 90th mer. time). At this station (lat. 32° 43′ N.; long. 97° 15′ W.) the altitude of the sun varied from approximately 23° to 18° 30′.

The angular measurements were secured by the use of the altazimuth, used by the writer in securing measurements of meteor paths. Although homemade, it has been found accurate and it is believed can be relied upon to within 20′ of a true measurement.

The altitude of the sun was measured three times, viz, $18^h\ 36^m\ 10^s$, $18^h\ 43^m\ 05^s$, and $19^h\ 06^m\ 10^s$, 75th meridian time. All other values in Table 1 are interpolated.

The correction necessary at this station to reduce 75th meridian time to local mean solar time is $-1^h\ 29^m$.

The radius of the arc was determined by measuring the altitude of the band at its point of maximum convexity, or on a line drawn from the zenith to the sun's position, the complement of this value being the radius value. It has been assumed throughout that the band maintained a constant width of 2°. The minute values have been given to as close a figure as possible and are believed to be within 5′ of the true measurement.

The horizontal position of the band was obtained by determining the approximate azimuth of either end. These values can not be trusted to within 5° because of the diffused character of the light at these points.

TABLE 1.

Time, 90th meridian.			Altitude of sun.		Solar distance.		The arc's— Radius.		The arc's— Limiting azimuths.
H.	*m.*	*s.*	*Deg.*	*min.*	*Deg.*	*min.*	*Deg.*	*min.*	*Degrees.*
17	**36**	**10**	**23**	**00**	**45**	**40**	**21**	**20**	**55–85**
17	37	10	22	52	45	42	21	26	55–85
17	38	00	22	43	45	42	21	35	58–85
17	39	10	22	34	45	43	21	43	60–86
17	40	20	22	24	45	44	21	52	62–86
17	41	00	22	18	45	44	21	58	65–88
17	42	10	22	09	45	45	22	06	65–88
17	**43**	**05**	**22**	**00**	**45**	**46**	**22**	**14**	**66–88**
17	44	10	21	50	45	46	22	24	68–88
17	45	10	21	42	45	47	22	31	70–88
17	46	00	21	34	45	48	22	38	70–90
17	47	00	21	25	45	49	22	46	74–90
17	48	10	21	16	45	50	22	54	78–90
17	49	20	21	05	45	51	23	05	80–90
17	50	10	20	56	45	51	23	13	82–92
17	55	10	20	12	45	55	23	53	85–92
18	00	00	19	27	46	01	25	31	88–92
18	**06**	**10**	**18**	**30**	**46**	**09**	**25**	**21**	**90–92**

DISCUSSION.

During the time of observation of this arc no evidence in any part of the sky of any other arc, halo, or optical phenomenon was noted. The skies were partly clouded, with about $\frac{6}{10}$Cu. and A.St. Local showers had occurred in various parts of the county prior to the time of the phenomenon, and a thunderstorm had passed south of the station within an hour previous.

Color.—The band of the arc was highly colored, the red nearest the sun, and at one or two of the observations the violet could be distinguished. The red seemed to be intensified at that point nearest the sun, or on an imaginary line from the sun to the zenith. As the observations progressed, the colors faded, leaving the red in prominence until at the last, $19^h\ 06^m\ 10^s$, 75th meridian time ($18^h\ 06^m\ 10^s$ by 90th mer. time), the phenomenon was little short of a red spot directly west of the zenith.

Dark line.—Beginning with the observation at $18^h\ 40^m\ 20^s$, 75th meridian time ($17^h\ 40^m\ 20^s$ by 90th mer. time), and ending with the observation at $18^h\ 44^m\ 10^s$ ($17^h\ 44^m\ 10^s$ by 90th mer. time), a very peculiar phenomenon was observed. The red circumzenithal arc was seen divided horizontally by a single dark line running the full length of the arc, into two bands whose widths were as 2 : 3, the narrower band being next the sun.

An attempt to photograph this phenomenon was unsuccessful, since the lens of the camera was not suited for the work.

The dark line faded rather abruptly and entirely within the minute elapsing between the observations at $17^h\ 44^m\ 10^s$ and $17^h\ 45^m\ 10^s$ (90th mer. time).

This dark line resembled the dark Fraunhofer lines of the spectrum, and this suggested the idea that it partook of the nature of the telluric spectral lines, which are due to absorption by the gases of our atmosphere. Perhaps some other observer has seen this peculiar line and given a better explanation of it.

ATMOSPHERIC ELECTRICAL VARIATIONS AT SUNSET AND SUNRISE.[1]

By E. H. NICHOLS.

[*Reprinted from* Science Abstracts, Sect. A, Aug. 25, 1916, § 916.]

Observations of the positive and negative charge per cubic centimeter, the air-earth current, and the conductivity were made with two Ebert electrometers and a Wilson compensating gold-leaf electroscope. Potential gradients were measured from the charts of the Kelvin water dropper. The two Ebert instruments were used to record the simultaneous values of the positive and negative charges per cubic centimeter. Three consecutive 5-minute readings were taken immediately before sunrise or sunset and three immediately after. Taking the means of the "15 minutes before" and of the "15 minutes after" sunset, it is apparent that a decrease of about 20 per cent occurs in all the quantities (positive charge, negative charge, air-earth current, and conductivity) at the time of sunset. The individual 5-minute readings show that this is not brought about by a sudden change at the instant of sunset, but by a gradual decrease throughout the whole 30 minutes in all the elements. The effect seems to be as strong in the winter months as in the summer. The *sunrise* readings show that the effect is not so pronounced at sunrise as at sunset. A similar investigation was carried out on the potential gradient, making use of two years' records from the water dropper. There is generally an increase in potential gradient both at sunrise and sunset. This is well marked in the winter but negligible in the summer. Again there is no sudden change at the instant of sunrise or sunset, but a gradual one throughout the 30 minutes.

The effect was tried of applying a correction for the diurnal variation of potential gradient at the appropriate time of day, and it was found that after doing this the sunrise and sunset effects were still apparent.—*J. S. Di*[*nes*].

IONIZATION OF THE UPPER ATMOSPHERE.[2]

By W. F. G. SWANN.

[*Reprinted from* Science Abstracts, Sect. A, June 26, 1916, § 711.]

From various points of view there are indications that the upper atmosphere is to be treated as a region of high electrical conductivity. One of the first theories which took this hypothesis as one of its bases, was that developed by Schuster to account for the diurnal variation of the earth's magnetism.[3] There are different sources to which the necessary ionization may be ascribed,

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[1] Proc., Royal Soc., London, July 1, 1916, 92:401–408.
[2] Terrestrial magnetism, March, 1916, 21:1–8.
[3] *See* Science Abstracts, 1908, § 1158.

but the most natural is that of the ultra-violet light from the sun. In the present paper some calculations are made to determine the possibility of this cause leading to the required effect. Considering first the fraction of the solar energy that is available for gaseous ionization (wave-length less than 135 $\mu\mu$), if the radiation from the sun is treated as black-body radiation, this is deduced to be 1.61×10^{-5} of the total energy entering the atmosphere. It is assumed that the ionization is confined to a layer 300 kilometers thick and the number of ions which will be produced per cubic centimeter per second by this energy is then calculated. Taking suitable values for the coefficient of recombination and the specific velocities of the ions in the high altitudes considered, the specific conductivity σ is next deduced to have a value of 8×10^4 electrostatic units. The value of σ required by Schuster is about 10^3 times as large as this. The above calculation is based on the assumption that the atmospheric pressure in the layer is 1 dyne per square centimeter, and the assumption of a smaller pressure provides a loophole out of the difficulty. A curious result which arises from a further calculation on these lines is that the conductivity of the atmosphere should theoretically tend to an infinite value with increase of altitude, if we assume the laws of variation of the various quantities with pressure—which hold at pressures that are measurable—to apply also with smaller pressures. The physical reason for this lies in the increase in the specific velocity of the ions with diminution of pressure, that is, with increase of altitude.—*J. S. Di[nes]*.

GROUND RAINBOWS.[1]

By A. E. HEATH.

[*Reprinted from* Science Abstracts, Sect. A, May 25, 1916, §526.]

Describes a colored bow similar to a rainbow of about the intensity of a good secondary rainbow, which was seen on the ground of a cricket field at about 11 a. m. on October 14, 1915. The sun was immediately behind the observer, and the bow appeared on the ground, starting from just in front of the observer s feet and stretching on either side in a sweeping curve away from the sun. The bow is explained as being due to sunlight refracted twice at the near surfaces and reflected once at the back surfaces of drops of water that had condensed on gossamer which covered the field. On this theory the angle between the directions of the incident and emergent rays is $42\frac{1}{2}°$ and the bow is the section by the ground, of the cone of which the semivertical angle is $42\frac{1}{2}°$, and the axis is the line joining the observer s eye to the sun. The bow will therefore be a circle, an ellipse, a parabola, or a hyperbola according as the sun is in the zenith, at an elevation of 42° to 90°, of 42°, or of less than 42°, respectively. The elevation of the sun was about 23° at the time of observation, and the bow was proved to be a hyperbola by pegging out its outline on the ground.[2]—*R. C[orless]*.

TEMPERATURE AND RADIATION OF THE SUN.[3]

By F. BISCOE.

[*Reprinted from* Science Abstracts, Sect. A, July 25, 1916, §757.]

The purpose of the first section of the paper is to determine the temperature of the sun from the intensity of radiation for individual wave lengths in its spectrum, using the observations from the Smithsonian Institution at Washington made with the spectrobolometer. The deduced absolute temperature of the solar surface is found to be on the average 7,300° ± 100°C. Other observations made by the author with the aid of color filters in conjunction with the Ångstrom compensation pyrheliometer are also examined for variations of solar radiation over small intervals of time.—*C. P. B[utler]*.

SOLAR CORPUSCULAR RAYS.[4]

By K. BIRKELAND.

[*Reprinted from* Science Abstracts, Sect. A, May 25, 1916, §531.

From the discussion of an extensive series of auroral observations Störmer has decided to regard the aurora as due to positive corpuscles emitted from the sun coming into action in the upper atmosphere of the earth. Birkeland considers that corpuscles are negative and brings forward the evidence given by his extensive experiments on the discharges from a magnetized kathode in a special vacuum chamber.—*C. P. B[utler]*.

AURORA OF SEPTEMBER 30, 1916.

Chesterbrook, Va.—At 8:05 p. m. (75th mer. time), or perhaps one or two minutes earlier, on the evening of Saturday, September 30, a glow was noted low in the north to north-northwest. Careful watching for several seconds made it seem probable that the light was in the form of radiating streamers which diverged slightly, the center being probably 20° to 40° below the horizon. The upper limit at which the streamers could be seen was hard to determine, as the light faded out gradually, but it was probably at least 20° above the horizon. No flickering was noted and no movement of the streamers, as wheeling around the center, was noticed. In all, the aurora was seen for perhaps two minutes; I then reached a neighbor's house where I stayed about 20 minutes. On coming out about 8:28 or 8:30 I looked again for the streamers but saw nothing. This aurora was observed at Chesterbrook, Fairfax County, Va., about 6 miles west or west by north of the heart of Washington, D. C.

One printed mention of this aurora has been noted, viz, in the "New Hampshire," a student's weekly publication at Durham, N. H., the location of the New Hampshire College of Agriculture and Mechanic Arts. In the issue of October 6 or 7 it was stated that a brilliant auroral display had been observed the preceding Saturday night [Sept. 30], the arch being conspicuous.—*Herbert C. Hunter, A. B.*

Alexandria Bay, N. Y.—On Saturday evening, September 30, 1916, a brilliant [auroral] display took place, although of exceedingly brief duration, the leading feature being the rose-red color of the lower fringe of a beautiful drapery which extended from within a few degrees of the northern horizon to about 35° above, the waves of light sweeping upward and in their rapid ascent changing to pale yellow and finally green at the upper limits of the aurora, as if the changing colors were due to the increasing rarity of the atmosphere met with in the passage of the auroral energy.—*Douglas Manning, Cooperative Observer.*

[1] Nature, London, Mar. 2, 1916, **97**: 5-6.
[2] See also in this connection *Whitmell, C. T.*, and *Knott, C. G.*, in Nature, London, Mar. 9, 1916, **97**: 34.
[3] Warsaw Univ. News, 1915. [In Russian.] Astrophys. Jour., April, 1916, **43**: 197-216 extract.
[4] *In* Archives des sciences, 1916, **41**: 22-37, 109-124.

SECTION II.—GENERAL METEOROLOGY.

THE PROBABLE GROWING SEASON.[1]

By WILLIAM GARDNER REED.

[Dated U. S. Office of Farm Management, Washington, July 24, 1916.]

Although the term "growing season" has been used to indicate the number of days between the last killing frost in Spring and the first killing frost in Fall,[2] the average length of this interval is not the time available for the growth of planted crops. The accompanying map in figure 2 (W. G. R., fig. 2, Chart XLIV-121) is an attempt to show the "probably available growing season" or the number of days without killing frost for which the chance is about four in five, the chance being computed in the same manner as insurance risks are determined. If losses from frost occur more frequently than one year in five, in the long run, the farmer is not likely to succeed. The second map (W. G. R., fig. 3) shows the dates on which begin the periods indicated in the map of the "available growing season" (fig. 2). This map shows the date on which the chance of killing frost falls to one in ten, or when the chance that there will be no later spring frost becomes nine in ten. The third map (W. G. R., fig. 4) shows the probable end of the growing season. The dates are those on which the chance of killing frost in Fall rises to one in ten, or when the chance of safety becomes less than nine in ten.

The average number of days without killing frost is considerably longer that that available for the growth of planted annuals, as may be easily seen from an examination of the characteristics of frost occurrence. For example, the frost record of Keokuk, Iowa, Table 1 and figure 1, shows that the average date of the last killing frost in Spring is April 15 and the average date of first killing frost in Fall is October 15; therefore, the average number of days without killing frost is 183. If the record is carefully examined, it will be seen, however, that a killing frost occurred in Spring later than the average date in 20 of the 43 years. This means that on the average date there has been only a 53 per cent (23 in 43) chance of safety. The study of all the available records for the United States shows that this approximately even chance of safety is a general condition; that is, crops above ground on the average date will be killed by spring frost in about half the years. This leaves only half the crops to be carried through the summer.[3]

The conditions obtaining for fall frosts are similar. The first killing frost in Fall at Keokuk occurred before the average date (October 15) in 21 of the 43 years. Of the 20 years when there was no killing frost in the spring after the average date, the first killing frost in Fall occurred before the average date in 8 years. In other words, the "average season without killing frost" was available for planted crops in only 12 of the 43 years, or in 28 per cent of the years. Unless the time required to mature the crop is much shorter than the "average season without killing frost" planting near the average date of last killing frost in Spring is out of the question even for high value crops. Successful farming can not be carried on if the loss from frost is as great as one in two, to say nothing of three in four.

The problem for the farmer is to select a planting date late enough to afford reasonable assurance of safety from spring frost and early enough to give the crop time to mature before the danger from Fall frost becomes too great. The "probably available growing season" then is the period between the time of reasonable safety in Spring and reasonable safety in Fall.

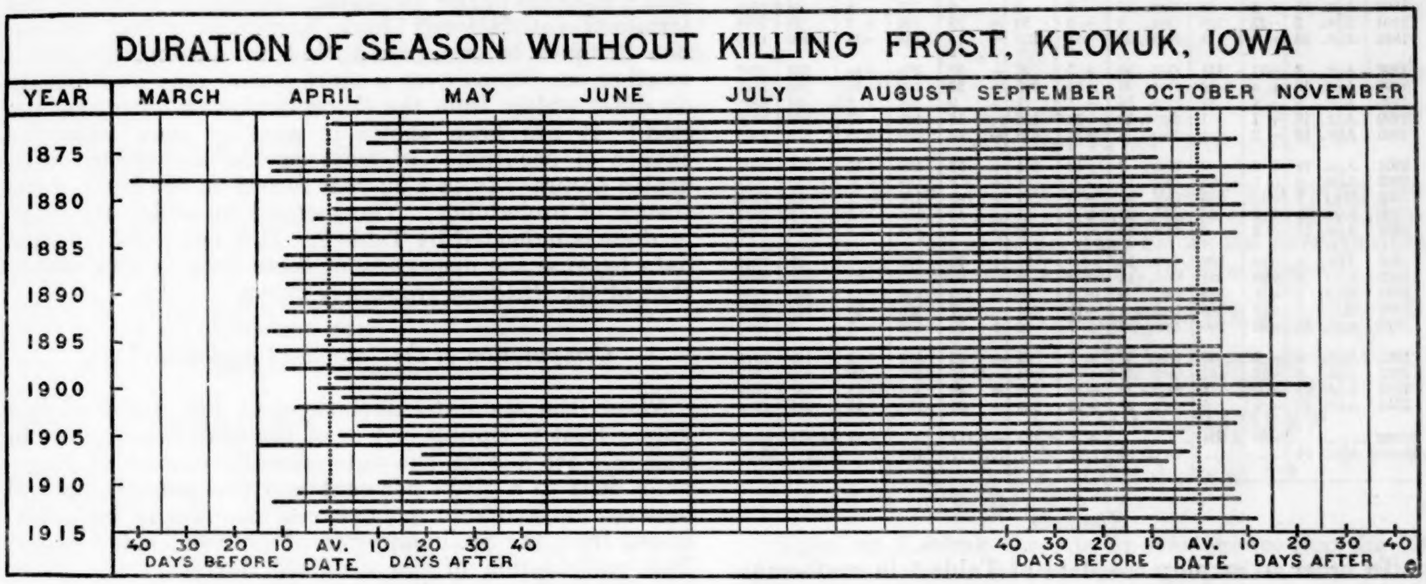

FIG. 1.—Duration of growing seasons at Keokuk, Iowa, 1872-1914, inclusive. (Average number of days without killing frost is 183.)

[1] Prof. W. J. Spillman, Chief of the Office of Farm Management, made the original suggestion leading to the study of the characteristics of the frequency distributions of climatic phenomena important in farm management investigations. This paper is one result of the study. The development and application of the mathematical theory is the work of Mr. H. R. Tolley of the Office of Farm Management.

Accompanied by Charts XLIV-121 to XLIV-123.

[2] *Day, P. C.* Frost data of the United States and length of the crop-growing season. (Weather Bur. Bul. V), Washington, 1911.

Fassig, O. L. The period of safe plant growth in Maryland and Delaware. MONTHLY WEATHER REVIEW 42: 152-158, Washington, 1914.

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[3] *Reed, W. G., & Tolley, H. R.* Weather as a business risk in farming. Geographical review, New York, 1916, 2: 48-53. *Abstract in* MONTHLY WEATHER REVIEW, June, 1916, 44: 354-5.

TABLE 1.—*Correlation of the last killing frost in Spring and the first killing frost in Fall, with the length of the season without killing frost at Keokuk, Iowa, 1872–1914, inclusive.*

Year.	Last killing frost in Spring.			First killing frost in Fall.			$d_s d_a$	Season without killing frost.			Year.
	s	d_s	d_s^2	a	d_a	d_a^2		l	d_l	d_l^2	
								Days.			
1872	Apr. 16	+1	1	Oct. 6	−9	81	−9	173	−10	100	1872
1873	Apr. 25	+10	100	Oct. 6	−9	81	−90	164	−19	360	1873
1874	Apr. 23	+8	64	Oct. 23	+8	64	+64	183	0	....	1874
1875	May 2	+17	289	Sept. 18	−27	729	−459	139	−44	1,936	1875
1876	Apr. 2	−13	169	Oct. 7	−8	64	+104	188	+5	25	1876
1877	Apr. 3	−12	144	Nov. 5	+21	441	−252	216	+33	1,089	1877
1878	Mar. 4	−42	1,764	Oct. 19	+4	16	−168	229	+46	2,116	1878
1879	Apr. 13	−2	4	Oct. 24	+9	81	−18	194	+11	121	1879
1880	Apr. 17	+2	4	Oct. 4	−11	121	−22	170	−13	169	1880
1881	Apr. 16	+1	1	Oct. 24	+9	81	+9	191	+8	64	1881
1882	Apr. 12	−3	9	Nov. 13	+29	841	−87	215	+32	1,024	1882
1883	Apr. 24	+9	81	Oct. 15	0	0	0	174	−9	81	1883
1884	Apr. 8	−7	49	Oct. 23	+8	64	−56	198	+15	225	1884
1885	May 8	+23	529	Oct. 6	−9	81	−207	151	−32	1,024	1885
1886	Apr. 6	−9	81	Oct. 1	−14	196	+126	178	−5	25	1886
1887	Apr. 5	−10	100	Oct. 12	−3	9	+30	190	+7	49	1887
1888	Apr. 20	+5	25	Sept. 29	−16	256	−80	162	−21	441	1888
1889	Apr. 6	−9	81	Sept. 27	−18	324	+162	174	−9	81	1889
1890	Apr. 10	−5	25	Oct. 19	+4	16	−20	192	+9	81	1890
1891	Apr. 7	−8	64	Oct. 20	+5	25	−40	196	+13	169	1891
1892	Apr. 6	−9	81	Oct. 23	+8	64	−72	200	+17	289	1892
1893	Apr. 23	+8	64	Oct. 15	0	0	0	175	−8	64	1893
1894	Apr. 2	−13	169	Oct. 9	−6	36	+78	190	+7	49	1894
1895	Apr. 14	−1	1	Sept. 30	−15	225	+15	169	−14	196	1895
1896	Apr. 4	−11	121	Oct. 20	+5	25	−55	199	+16	256	1896
1897	Apr. 19	+4	16	Oct. 29	+14	196	+56	193	+10	100	1897
1898	Apr. 6	−9	81	Oct. 14	−1	1	+9	191	+8	64	1898
1899	Apr. 16	+1	1	Sept. 29	−16	256	−16	166	−17	289	1899
1900	Apr. 13	−2	4	Nov. 8	+24	576	−48	209	+26	676	1900
1901	Apr. 18	+3	9	Nov. 3	+19	361	+57	199	+16	256	1901
1902	Apr. 8	−7	49	Oct. 14	−1	1	+7	189	+6	36	1902
1903	May 1	+16	256	Oct. 24	+9	81	+144	176	−7	49	1903
1904	Apr. 21	+6	36	Oct. 23	+8	64	+48	185	+2	4	1904
1905	Apr. 17	+2	4	Oct. 12	−3	9	−6	178	−5	25	1905
1906	Apr. 1	−14	196	Oct. 10	−5	25	+70	192	+9	81	1906
1907	May 4	+19	361	Oct. 13	−2	4	−38	162	−21	441	1907
1908	May 2	+17	289	Oct. 9	−6	36	−102	160	−23	529	1908
1909	May 2	+17	289	Oct. 4	−11	121	−187	155	−28	784	1909
1910	Apr. 25	+10	100	Oct. 22	+7	49	+70	180	−3	9	1910
1911	Apr. 9	−6	36	Oct. 22	+7	49	−42	196	+13	169	1911
1912	Apr. 3	−12	144	Oct. 23	+8	64	−96	203	+20	400	1912
1913	Apr. 13	−2	4	Sept. 22	−23	529	+46	162	−21	441	1913
1914	Apr. 12	−3	9	Oct. 27	+12	144	−36	198	+15	225	1914
Sums	....	−30	5,904	....	+5	6,487	−1,111	......	+35	14,612	Sums
Means	Apr. 15	.....	......	Oct. 15	.....	......	....	183	.....	......	Means

Symbols.

In order to employ the data of Table 1 in mathematical investigations it is necessary to employ the shorthand of mathematics, viz, symbols. Those used in this paper include the conventional ones generally adopted for investigations in "probability," and they are listed below for convenience of reference. In a previous similar study [4] the author made use of other symbols which did not employ Greek letters; these previous symbols are given in [] after the appropriate explanation.

s is the date of last killing frost in Spring in any year.
a is the date of first killing frost in Fall in any year.
l is the number of days between s and a in any year.
A_s is the average date of last killing frost in Spring. [M_s]
A_a is the average date of first killing frost in Fall. [M_a]
A_l is the average number of days without killing frost. [M_l]
A_s' is some arbitrary number near A_s. [M_s']
A_a' is some arbitrary number near A_a. [M_a']
A_l' is some arbitrary number near A_l. [M_l']
d_s is the departure of s from A_s'. [X_s']
d_a is the departure of a from A_a'. [X_a']
d_l is the departure of l from A_l'. [X_l']
n is the number of observations. [n]
σ_s is the standard deviation of s. [D]
σ_a is the standard deviation of a.
σ_l is the standard deviation of l.
r is the coefficient of correlation.
E_r is the probable error of r.
Σd_s, etc., algebraic sums of d_s, etc. [r]
Σd_s^2, etc., algebraic sums of d_s^2, etc. [$S(X')^2$]

If crops are to be planted intelligently, the farmer must know the chance of frost occurrence on any date in both Spring and Fall. There would be no difficulty in determining the chance in the long run if the records were of sufficient length—that is, at least 100 years, or still better 500. For the United States, however, the longest frost record is but 59 years, and there are but 671 complete records of 20 years or more, although there are 116 additional 20-year records with one or more years missing. [The theoretical probability can be determined satisfactorily from numerous short records, but it must be recognized that in nature the actual weather conditions over a short period may and usually do differ widely from the theoretical ones for a long period.] It has been shown in another place [5] that the chance of occurrence of frost can be determined with usable accuracy from a 20-year record on the basis of the theory of probability. The method by which this may be done is indicated by Table 2. It is applicable to frost data because the dispersion of these data follows closely that of the "normal frequency curve."

Computation of the "standard deviation," etc.

When the standard deviations of the dates of last killing frost in Spring (σ_s) or of the first killing frost in Fall (σ_a) are known, the date when the chance of occurrence falls to a given per cent and the average interval between unfavorable occurrences may easily be determined from the Spillmann curve [6] or from Table 2 below. The computation of the standard deviation and other quantities referred to later is as follows.

It appears from the last two lines of Table 1 that—

$\Sigma d_s = -30$ $A_s' =$ April 15 $A_s =$ April 15	$\Sigma d_a = +5$ $A_a' =$ Oct. 15 $A_a =$ Oct. 15	$\Sigma d_s d_a = -1111$	$\Sigma d_l = +35$ $A_l' = 183$ $A_l = 183$

The value of the standard deviation, σ, is computed by the formula

$$\sigma = \sqrt{\frac{\Sigma d^2}{\text{n}} - \left(\frac{\Sigma d}{\text{n}}\right)^2} \tag{1}$$

and successive substitutions in (1) give the following values:

$$\sigma_s = \sqrt{\frac{5904}{43} - 0.49} = 11.7 \text{ days} \qquad \sigma_a = \sqrt{\frac{6487}{43} - 0.01} = 12.3 \text{ days} \qquad \sigma_l = \sqrt{\frac{14612}{43} - 0.66} = 18.4 \text{ days.}$$

[4] *Spillmann, W. J. & others.* The average interval curve and its application to meteorological phenomena. MONTHLY WEATHER REVIEW, April, 1916, 44: 197-200, with plate.

[5] *Reed, W. G. & Tolley, H. R.*, op. cit. *Spillman, W. J., & others*, op. cit.

[6] *See* MONTHLY WEATHER REVIEW, April, 1916, 44, chart facing p. 198.

A possible relation between these values may be revea by computing the correlation coefficient, r, according to the usual formula which is stated in (2).

$$r=\left\{\frac{\Sigma d_s d_a}{n}-\left(\frac{\Sigma d_s}{n}\right)\left(\frac{\Sigma d_a}{n}\right)\right\}\div\sigma_s\sigma_a, \quad (2)$$

$$=\left\{\frac{-1111}{43}-\left(\frac{-30}{43}\right)\left(\frac{5}{43}\right)\right\}\div(11.7\times 12.3),$$

$$=-0.179.$$

One may also determine the standard deviation of the season without killing frost, σ_l, from the following equation given by Yule[7]:

$$\sigma_l^2=\sigma_s^2+\sigma_a^2-2r\sigma_s\sigma_a, \quad (3)$$

$$=136.89+151.29-(-51.52),$$

$$=339.70$$

therefore

$$\sigma_l=\sqrt{339.70}=18.4.$$

The existence of the residual $2r\sigma_s\sigma_a$ shows that mathematically the dates of last spring and first fall frost can not be regarded as independent. However, if E_r, the probable error of r, is calculated from the usual formula[8] it will be seen to be large when compared with the value of r.

Thus

$$E_r = \pm 0.67\ \frac{1-r^2}{4\sqrt{n}} \quad (4)$$

$$= \pm 0.674\frac{1-0.0321}{6.6}$$

$$= \pm 0.099$$

TABLE 2.—*Chance of frost occurrence, by the theory of probability, based on a 20-year record whence the standard deviations are known.*

[See p. 510 for explanation of symbols.]

Chance of frost.	Chance of safety.	Spring.	Fall.
Per cent.	*Per cent.*		
50	50	A_s	A_a
40	60	$A_s+0.25\sigma_s$	$A_a-0.25\sigma_a$
30	70	$A_s+0.52\sigma_s$	$A_a-0.52\sigma_a$
25	75	$A_s+0.67\sigma_s$	$A_a-0.67\sigma_a$
20	80	$A_s+0.84\sigma_s$	$A_a-0.84\sigma_a$
10	90	$A_s+1.28\sigma_s$	$A_a-1.28\sigma_a$

The chance that a definite period extending through the Summer will be free from killing frosts may be computed from the chance that it will be free from killing frost at the beginning and at the end. In mathematical terms this is as follows: The probability that two independent events should both happen is the product of the separate probabilities of their happening. It can be shown that the longest period with any given chance of safety from killing frost will be that when the chance of killing frost in the early part (Spring) is equal to the chance of killing frost in later part (Fall), the middle part (Summer) being practically always frost free in the strictly agricultural regions.

The mathematical statement of the problem is as follows:

Let P' = the chance that the selected period will be frost free.

P_s = the chance of safety in Spring.

P_a = the chance of safety in Fall.

and $P_s=P_a=P$

$$P\times P=P'$$

$$P^2=P'$$

$$P=\sqrt{P'}$$

This may be applied to any case under consideration; for example, the frost record at Keokuk, Iowa, as given by Table 1, may be studied. On the average date in Spring (April 15) $P_s=0.50$ and on the average date in Fall (October 15) $P_a=0.50$.

Then $P=0.50$

$$P^2=0.25$$

but $P^2=P'$

$$P'=0.25 \text{ or } 25 \text{ per cent}$$

which is not far from the 28 per cent shown by counting the cases; in fact it is within the variation to be expected as a result of the small number of observations.

It is equally easy to find the length of the season in which the chance of killing frost is even, that is, 50 per cent.

Here

$$P'=0.50$$

$$P^2=0.50$$

$$P=\sqrt{0.50}$$

$$=0.71 \text{ or } 71 \text{ per cent.}$$

Table 2 shows that the chance of safety in spring rises to 70 per cent at $0.52\sigma_s$ days after the average and falls to 70 per cent in fall at $0.52\sigma_a$ days before the average date, so that at Keokuk (see Table 1), for example—

$$A_s = \text{April 15 (14.3)*}$$

$$\sigma_s = 11.7$$

$$A_s+0.52\ \sigma_s = \text{April 21 (20.4)*}$$

$$A_a = \text{October 15 (15.1)*}$$

$$\sigma_a = 12.3$$

$$A_a-0.52\sigma_a = \text{October 8 (8.7)*}$$

$$\text{April 21 to October 8} = 170 \text{ days.}$$

Thus, at Keokuk there is an even chance that the 170 days from April 21 to October 8 will be free from killing frost. An examination of the Keokuk record shows that there actually were 26 years between 1872 and 1914 in which there were more than 170 days beginning with April 21 on which killing frost did not occur. This is a chance of 60 per cent and, if the years represent a fair sample of the conditions at Keokuk, it shows that the calculated season is a little too short. The explanation of this is to be found in the fact that during the years studied the first killing frost of Fall sometimes came late in years when the last killing frost in Spring was early, and vice versa. That is, there is a doubtful tendency toward "negative correlation," as is shown by the fact that there is a residual ($2r\sigma_s\sigma_a$) in equation (3) in which r (the coefficient of correlation[9]) has a value of -0.179. But the probable error of this coefficient is so large (0.099) when compared with its value, that correlation remains doubtful. The fact that this condition is persistent in most

[7] *Yule, G. Udney.* Introduction to the theory of statistics. 2d ed. London, 1912. p. 210–211.
[8] *Yule, G. U.* Op. cit., p. 352–353.

* All fractions are added in Spring and dropped in Fall.
[9] *Smith, J. Warren.* Correlation. MONTHLY WEATHER REVIEW, May, 1911, 39: 792–795.

records is, perhaps, significant. At any rate, the existence of the residual due to the apparent value of r must be considered in any such comparison as this. Only when the value of r is zero does the residual disappear. In the computation of risk, however, it is better to assume that there is no negative correlation between the date of last killing frost in Spring and first killing frost in Fall, as this gives a small margin of safety.

SIGNIFICANCE OF THE CHARTS.

The limiting dates of the season with any other chance of safety may be determined in the same manner. A consideration of the agricultural conditions and of the planting dates of grain crops leads to the belief that the risk of frost damage may reasonably be carried when the chance of killing frost falls to 1 in 10 and that crops should generally be harvested before the chance of killing frost in Fall has risen much above that ratio. If these dates are observed, the available growing season is that which may be expected to occur in about four-fifths of the years. That is—

$$P_s = 0.90$$
$$P_a = 0.90$$
$$0.90 \times 0.90 = P'$$
$$P' = 0.81 \text{ or about } 4/5.$$

The results are, of course, the same if it be assumed that a season free from killing frost in about four years in five is required for successful agriculture.

Here

$$P' = 0.80$$

but

$$P' = P^2$$

then

$$P^2 = 0.80$$
$$P = \sqrt{0.80}$$
$$P = 0.894$$
$$= 9/10 \text{ (approx.)}$$

therefore

$$P_s = 9/10$$
$$P_a = 9/10$$

The maps presented as figures 3, 4, and 5 (charts XLIV-121 to 123) are intended to supplement rather than to supersede the maps showing average conditions. The usual maps of average conditions will continue to be more accurate for the information they are able to give, viz, the dates after or before which the chance of frost is 1/2 and the length of the season available in 1/4 of the years, because many more data are available for their construction. The new charts presented with this paper attempt to furnish information about more closely calculated periods, by means of which the degree of certainty of freedom from frost may be better calculated and farm practice accordingly better adapted to the natural conditions of the region. In general it appears that the chance of killing frost falls to 10 per cent between 10 and 30 days after the average date of the last killing frost in Spring; in the Fall the corresponding difference is about the same. In general any station has a dispersion in Spring similar to that in Fall (i. e., σ_s and σ_a are nearly equal).

In the attempt to use any generalized maps of frost conditions allowance must be made for local variations. Any maps of the United States as a whole on the scales practicable for this REVIEW, can show only the general conditions over wide areas. Within these areas the more favored places will be much less subject to frosts and will have much longer available growing seasons than those indicated by the map, while the less favored spots will have later spring and earlier fall frosts with resulting shorter growing seasons. The chance of killing frost or of a frost-free season of any given length for a station may be determined, from such maps as those accompanying this paper, by applying a correction for local conditions, and this correction must be determined for each place. The necessity of this local correction is not limited to these data but applies with equal force to all maps of average dates or conditions.

CERTAIN CHARACTERISTICS OF THE WINDS AT MOUNT TAMALPAIS, CAL.

By HERBERT H. WRIGHT, Assistant Observer.

[Dated: Weather Bureau, Mount Tamalpais, Cal., July 12, 1916.]

Mount Tamalpais, Cal., while only about 2,600 feet above sealevel, rises so abruptly from the low, surrounding country that it is specially adapted for securing wind data. Topography has little or no effect on the directions or velocities recorded.

In Table 1 will be found the prevailing wind directions for the months and for the year at Mount Tamalpais, computed for the 13 years 1899 to 1911, inclusive. The persistency of the northwest wind along this coast is quite marked, as this table shows. As lower levels are reached there is a tendency for the wind to blow more from the west, specially during the summer. In winter, at sealevel, the prevailing direction for a few months is southerly.

TABLE 1.—*Prevailing wind directions at Mount Tamalpais, 1899–1911 inclusive.*

Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
SE.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.	NW.

The southeast winds at Mount Tamalpais during January are due to the fact that it is midwinter, the period of greatest storm frequency, and the LOWS follow each other in such rapid succession that the winds prevalent during fair weather have little influence in determining the prevailing direction at this season.

TABLE 2.—*Average hourly wind velocities at Mount Tamalpais, Cal. (2,604 feet), 1899–1911, inclusive.*

[Miles per hour for the hour ending —]

Month.	A. M.												P. M.												Mean.
	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	12	
January	19.6	20.4	20.6	20.8	20.4	20.5	20.0	21.0	20.3	19.0	18.0	17.1	16.5	16.5	17.0	17.6	18.8	19.8	20.2	21.0	21.1	21.6	21.3	20.9	19.7
February	21.4	21.5	21.3	21.4	21.2	21.2	21.0	20.0	22.2	16.7	15.4	14.3	14.2	14.1	14.6	15.5	17.0	18.9	20.4	20.7	21.1	21.2	21.5	21.3	18.9
March	21.8	21.8	21.3	21.2	21.0	20.8	20.4	18.8	17.1	15.9	14.5	13.9	14.0	14.2	15.2	16.4	17.2	18.9	20.4	21.3	22.0	22.0	21.9	21.7	18.9
April	21.8	21.8	21.7	21.5	21.2	20.7	19.4	17.4	15.0	12.9	11.7	10.9	11.2	11.9	13.1	15.0	15.4	19.3	21.2	22.7	23.4	23.6	23.0	22.3	18.3
May	24.2	24.3	24.3	23.9	23.1	21.9	19.3	16.5	13.8	11.6	10.7	11.0	11.9	12.4	14.6	16.9	19.7	22.5	24.8	26.9	27.1	26.4	25.6	24.8	20.0
June	24.1	23.5	22.8	22.8	22.0	20.3	18.1	15.5	14.0	11.0	9.7	9.2	9.4	10.0	11.4	13.8	16.6	19.1	21.8	24.1	25.4	25.4	25.2	24.7	18.3
July	20.4	19.5	19.2	18.8	18.0	16.7	14.7	12.9	11.5	9.4	8.0	7.2	7.0	7.5	8.6	10.5	13.0	15.8	17.8	19.7	20.8	21.9	21.7	20.9	15.1
August	17.8	17.4	17.2	16.6	15.9	15.0	13.5	11.6	10.1	8.7	7.8	7.3	7.5	7.9	9.0	10.8	12.9	14.8	17.3	18.9	19.8	20.1	19.6	18.6	14.0
September	18.1	17.8	17.6	17.6	17.7	17.1	15.7	13.8	12.1	10.4	9.5	9.1	9.2	9.5	10.4	12.2	14.4	16.4	18.1	19.3	20.1	20.2	19.8	18.9	15.2
October	18.0	18.4	18.3	18.4	18.6	18.5	18.0	17.1	15.6	14.3	13.1	11.8	11.4	11.6	12.6	14.2	15.9	17.2	18.0	18.4	18.6	18.1	17.8	17.8	16.4
November	19.1	18.9	19.0	19.2	19.4	19.6	19.1	18.9	17.5	16.3	15.0	13.8	13.0	13.2	13.6	14.9	16.8	18.4	18.0	19.1	19.0	19.2	19.1	19.0	17.5
December	21.0	21.1	21.0	21.1	21.1	21.2	21.3	21.2	20.3	19.5	18.7	17.6	16.8	16.5	17.1	17.8	19.1	20.3	20.2	20.6	20.7	20.8	20.9	21.0	19.9
Year	20.6	20.5	20.4	20.3	20.0	19.5	18.4	17.1	15.8	13.8	12.7	11.9	11.8	12.1	13.1	14.6	16.4	18.4	19.8	21.1	21.6	21.7	21.4	21.0	17.7

TABLE 3.—*Average hourly wind velocities at San Francisco, Cal. (220 feet), 1899–1911, inclusive.*

[Miles per hour for the hour ending —]

Month.	A. M.												P. M.												Mean.
	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	12	
January	6.3	6.4	6.4	6.4	6.4	6.4	6.6	6.8	6.9	7.3	7.5	7.4	7.8	8.1	8.0	8.0	7.9	7.7	7.4	7.1	6.9	6.6	6.3	6.3	7.1
February	6.1	5.8	5.7	5.7	5.6	5.6	5.8	6.0	6.4	7.0	7.2	7.4	8.1	8.8	9.3	9.5	9.6	9.3	8.9	8.2	7.4	7.1	6.7	6.2	7.2
March	7.2	6.9	6.8	6.6	6.4	6.6	6.3	6.7	7.1	7.8	8.2	8.8	10.0	11.0	12.1	12.8	12.7	12.4	11.5	10.5	8.7	8.3	7.8	7.3	8.8
April	7.3	7.0	6.7	6.3	6.1	6.0	6.0	6.5	7.2	7.7	8.4	9.8	12.0	13.3	14.3	15.2	15.3	14.8	13.8	12.5	11.1	10.0	9.1	8.1	9.8
May	8.5	7.8	7.2	6.9	6.6	6.2	6.4	6.6	7.0	7.9	9.4	11.5	14.0	15.2	16.5	17.1	17.1	16.6	15.5	14.3	12.7	11.2	10.2	9.1	10.9
June	9.3	8.9	8.3	7.7	7.5	7.1	6.9	7.3	7.8	8.7	10.5	12.2	15.8	17.5	18.8	19.4	19.7	19.2	18.1	16.4	14.9	13.0	11.5	10.1	12.4
July	9.9	9.3	8.6	8.2	7.8	7.5	7.5	7.5	7.8	8.5	10.4	13.0	15.4	17.7	19.3	20.4	20.8	20.1	18.9	17.0	15.3	13.7	12.4	10.9	12.8
August	9.3	8.7	8.1	7.8	7.4	7.2	7.1	7.2	7.5	8.2	9.8	11.9	14.6	16.6	18.3	19.3	19.6	18.7	17.5	15.7	14.0	12.6	11.3	10.0	12.0
September	7.3	6.9	6.4	6.0	5.6	5.4	5.3	5.5	5.8	6.3	7.5	9.5	11.8	13.5	15.2	16.4	16.7	16.2	14.5	12.8	11.4	10.1	8.8	7.9	9.7
October	5.8	5.4	5.3	5.2	4.9	4.7	4.9	5.2	5.6	6.0	6.1	7.0	8.9	10.2	11.4	12.1	12.6	11.9	10.4	9.0	8.0	7.1	6.6	6.2	7.5
November	5.4	5.5	5.3	5.3	5.2	5.2	5.3	5.5	5.7	6.0	6.3	6.6	7.1	7.6	8.2	8.7	8.8	8.5	7.8	7.3	6.7	6.3	6.1	5.8	6.5
December	5.5	5.6	5.6	5.6	5.7	5.7	5.7	5.9	6.3	6.5	6.6	6.8	7.1	7.0	7.0	6.9	6.7	6.5	6.1	5.9	5.8	5.8	5.6	5.6	6.1
Means	7.3	7.0	6.7	6.5	6.3	6.1	6.2	6.4	6.8	7.3	8.2	9.3	11.0	12.2	13.2	13.8	13.8	13.5	12.5	11.4	10.2	9.3	8.5	7.8	9.2

According to some authorities, wind velocities at low levels are greatest during the day, decrease toward nightfall, and approach a calm during the middle of the night. This order is exactly reversed on Mount Tamalpais. Table 2, giving the average hourly velocities, from 13 years record, 1899 to 1911, inclusive, shows a minimum velocity near noon. The corresponding maximum does not occur until about 9 p. m. This is shown in graphic form in figure 1, where the average velocities at this station are compared graphically with similar data for San Francisco.

The rapidity with which the velocity decreases toward midday at the upper station is shown in marked contrast to the rapid rise in velocity at the lower. Greater contrasts, of course, would be found in the daily records as a drop within an hour from 50 mis./hr. to 10 mis./hr. is not uncommon at this station.

The high winds experienced on Mount Tamalpais are, as a rule, quite gusty. These gusts are seldom shown on the automatic register save during exceptionally high winds because each gust is of so short duration. The Robinson anemometer in present general use in the Weather Bureau records the average rather than the extreme velocities. Extreme velocities of 140 mis./hr. have been recorded at Mount Tamalpais, however, and it is probable that could the individual gusts be measured accurately much higher velocities would be found.

Relations between wind velocity and temperature.—At lower levels there seems to be a direct relationship between the time of maximum temperature and maximum wind velocity, both occurring at or near the same time. No such relationship exists at this elevation nor does there seem to be any definite connection between the two elements in that respect. The reverse condition, however, is more nearly the case, for the maximum temperature occurs on the average at 2 p. m. which is about two hours after the minimum wind velocity. The minimum temperature, though, comes near 6 a. m., a time when wind velocities are still high. It thus appears that no

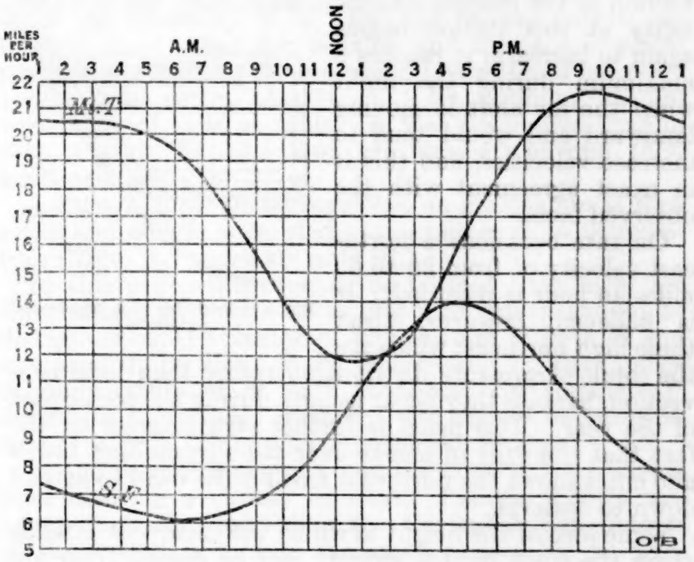

FIG. 1.—Hourly march of average wind velocities at Mount Tamalpais (2,604 feet) and at San Francisco, Cal. (220 feet). (1899–1911)

definite relationship exists at this level between temperature and wind velocity.

The decrease in velocity during the middle of the day on the mountain is doubtless due to temperature. This

decrease is most marked during the warmer half-year, the season when convection is greatest. The air over the interior valleys becomes warmed under the intense insolation and expands upward, causing a slight pressure gradient which increases with elevation. The air then starts to flow down this gradient toward the ocean and the cool air over the ocean flows landward to replace the warmed air flowing off aloft (figs. 2 and 3). At night, the air over the ocean is warmer than that over the land owing to the more rapid radiation of the land surface, and the reverse action takes place, a landward breeze aloft and a seaward breeze below. This is the theory of the origin of the land and sea breeze.[1]

Mount Tamalpais probably penetrates the lower part of the transition zone between this seaward upper wind and the landward lower current. Therefore light variable winds would be expected during the time these convection-caused currents are operating.

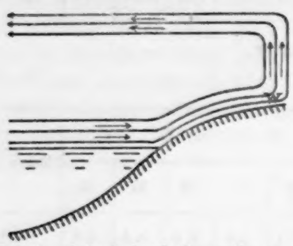

FIG. 2.—Actual circulation under seabreeze conditions (Sandström).

From observations of cloud movement, this upper seaward current is believed to blow from the northeast. Clouds are seldom recorded as moving from easterly quarters, but when they are the direction is almost always from the northeast. This freedom from clouds in this air current is probably due to adiabatic heating.

The decrease in velocity at this elevation is simultaneous with the beginning of convection in the interior valleys, i. e., about 9 a. m. It is thought, then, that the outflowing air aloft, descending as it progresss, tends to cause a change in the wind direction at this level in a clockwise direction, since during the middle of the day north and northeast winds are often recorded. This easterly wind flowing seaward at high altitudes, if it is not always strong enough to cause a change in the regular wind direction, will at least interfere and cause a decrease in velocity. In the middle of the afternoon, when convection in the interior valleys is decreasing, the wind velocity at this station begins again to increase; it reaches a maximum during the night when the air aloft is moving landward and would tend to increase velocities, and this is in exact agreement with the observed facts.

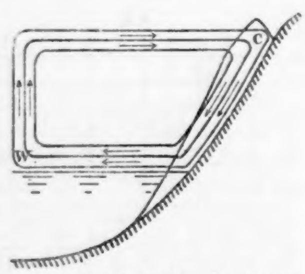

FIG. 3.—Circulation of a land-breeze (Sandström).

On rare occasions a northeast velocity of from 30 to 60 miles an hour is recorded. It is believed, however, that these high northeast winds are the result of pressure distribution rather than local convection, because they occur usually during the cooler part of the year. This belief is further strengthened by the fact that the drift of smoke over the surrounding towns and cities shows the northeast trend ofthe wind to extend down to sealevel.

Some idea of the height to which the seabreeze extends along the coast in this vicinity can be gained from observations made on Mount Tamalpais during periods when fog is prevalent over adjacent lowlands and over the ocean, a frequent condition during extended periods in summer. The estimated average height of the seabreeze in this vicinity is between 800 and 1,000 feet, assuming that it does not extend above the upper limits of the fog. This seems probable, since the main cause of fog along this coast is believed to be the mixture of air masses having different temperatures and relative humidities. There is no reason to believe that this mixture does not extend to the upper limits of the moisture-bearing wind.

Another fact that seems to strengthen the belief that the seabreeze does not extend to this level is the difference in time between the beginning of the wind at sealevel and the beginning at this elevation. In the former case the time is the middle of the forenoon, while it is retarded until the middle of the afternoon in the latter. The converse would be expected, since the surface wind encounters more friction, which would tend to retard it and cause it to lag behind the wind at somewhat higher levels.

Still another argument in favor of this hypothesis is the low relative humidity sometimes recorded at this station when the wind is northwest. For example, the case of June 13, 1916, at 5 a. m., can be cited. Fog covered the entire surrounding country below the station. The wind here was light northwest, the temperature 68.5°F., 15 to 20 degrees warmer than the air at sealevel, and the relative humidity but 5 per cent. To produce saturation, this air would have had to be cooled to 0° F. Were this wind a true seabreeze coming off the ocean, the relative humidity could not be so low, nor would the temperature be so high. It seems more likely that it was part of the upper seaward current, after it had begun to descend and start landward. Mount Tamalpais, being so near the ocean and relatively high, would not be a great distance from this turning point. This, too, would explain the anomalous, vertical temperature distribution.

[1] Sandström, *in* Bull., Mt. Weather Obsy., 1912, 5: 90, fig.

RAINFALL ON DAYS WITH AIR TEMPERATURE BELOW THE FREEZING POINT.[1]

By S. TAKAYAMA.

(Abstract.)

When the air temperature near the earth's surface is below the freezing point [0°C.] precipitation generally takes the form of snow. But there are many instances of the falling of ordinary raindrops in the hours during which the mercury stands far below the freezing point. The author has picked out 36 cases in all from the meteorological registers kept at the meteorological observatories at Hakodate, Sapporo, and Nemuro for the 15 years from 1897 to 1912. In the large majority of the cases air temperature was ranging between 0° and −2°C. There were three cases in which the temperature was below −5°C. In one instance it was as low as −7.8°C.

The phenomenon under consideration occurs mostly in the early morning or at night, and is rarely observed in the daytime. Its duration is mostly less than 30 minutes, and the amount reaches scarcely a millimeter. [In Japan] this phenomenon occurs mostly with strong winds or gales from the east.

In the 36 cases referred [to] above, 8 cases were preceded by snow, 2 cases by soft hail [graupel], and 7 cases by sleet [frozen rain drops?]. In two cases it occurred with fogs. In the remaining 14 cases it was raining from beginning to end.

According to the author there are two causes of this abnormal phenomenon. In most cases it may be explained by assuming the existence of the inversion in the

[1] *Reprinted from* Journal, Met'l. soc. Japan, January, 1916, 35:37-8.

vertical distribution of air temperature. In some cases the raindrops are supposed to have been formed in the warm upper current of air and to have fallen to the earth's surface where air temperature is below the freezing point. In the other cases this phenomenon may be explained by assuming that the raindrops have been formed in the ascending current of air highly supersaturated with aqueous vapor. From thermodynamical considerations the author has shown that when the condensation takes place continuously in the highly supersaturated air, both snow crystals and raindrops are formed even though the air temperature is many degrees below the freezing point.—*T. O[kada]*.

NEWTONIAN CONSTANT OF GRAVITATION AS AFFECTED BY TEMPERATURE.[1]

By P. E. SHAW.

[*Reprinted from* Science Abstracts, Sect. A, Aug. 25, 1916, §860.]

This paper deals with the possible existence of a temperature coefficient in the law of gravitation and gives an account of experiments made to discover this coefficient. The apparatus used is of the Cavendish torsion-balance type, and the range of temperatures was from 15° to 250°C. The investigation has extended over a number of years and was carried out in a vault of the physics department of University College, Nottingham. It yields evidence for a positive temperature effect of gravitation and measures its value.

The accumulation of negative results in the experimental study of gravitation is remarkable. In consequence of the indifference of the gravitative force to changes of conditions (other than those given by the simple law $f = \mathrm{GM}md^2$), none of the many theories of gravitation so far propounded has received general acceptance for lack of data wherewith to test them. Some recent theories which consider the possibility of temperature effect are the following: N. Morazov (1908) advanced a wave theory in which the attraction of masses would vary with temperature; G. Mie (1913) gave a theory of matter which includes among its corollaries a temperature coefficient of 10^{-13} per degree C. to the so-called Newtonian constant; N. Bohr (1913), in a paper on the constitution of the atom, assumed that gravitation like radioactivity is unaffected by all physical and chemical agencies.

Previous determinations of the Newtonian constant have been made at ordinary temperatures only, special care being taken to maintain uniformity in temperature throughout the apparatus used; otherwise convection in the air or strains in the movable system might produce grave errors. This is shown repeatedly in the well-known researches by C. V. Boys and J. H. Poynting. The necessity of providing a steady temperature about the delicate parts of the apparatus has previously been considered an insuperable bar to any direct experiment to discover a temperature effect for G. Yet indirect investigations have been made. Poynting and Phillips (1905) counterpoised a mass of 208 gm. on a balance and varied its temperature between 100° and −186°C. They came to the conclusion that the resulting change in weight, if any, was less than 10^{-9} per degree C. for the range 100° to 0°C., and 10^{-10} per degree C. for the range 0° to −186°C.

Another balance experiment on change in weight with temperature by Southerns (1906) led to a somewhat similar result.

In looking for a method to continue and extend these researches it is observed that a weight of say, 1 gm., can be determined on a balance to 10^{-8} under favorable conditions, whereas in a gravitation apparatus, like that of C. V. Boys, the attraction of one mass on another can not be found with greater accuracy than 10^{-5} at the utmost. Thus, apart from other reasons, it would be futile on the latter type of apparatus to look for a temperature effect between 100°C. and −186°C. on the small mass, m, since the above negative results have established the case with the greatest possible accuracy. But, in these balance experiments of Poynting and Phillips, the large mass M (in their case the earth) was unchanged in temperature. Now M is incomparably larger than m and might have a preponderating influence, whereby change of *its temperature alone* would affect the mutual attraction. In the work referred to, Poynting and Phillips suggested (though without any a priori grounds) the feasibility of some such expression as the following:

$$f = \mathrm{G}\left[1 + \mathrm{K}\frac{\mathrm{M}t + mt'}{\mathrm{M} + m}\right]\frac{\mathrm{M}m}{d^2}, \qquad (1)$$

where K is a temperature coefficient and t, t' are increments in temperatures of M and m. When M/m is very great, this reduces to

$$f = \mathrm{G}(1 + \mathrm{K}t)(\mathrm{M}m/d^2) \qquad (2)$$

so that, on the above supposition, the mutual attraction would be influenced by change in temperature of the large mass only.

Admitting the possibility involved in (2), weight experiments must be abandoned in the endeavor to detect a temperature effect in gravitation and an apparatus adopted, having both masses (M and m) under control as regards temperature.

It is supposed by some that Kepler's third law establishes the constancy of G. But the present author has tried to show[2] that this is false, and that the common practice of obtaining the masses and densities of heavenly bodies (sun, earth, planets, etc.) by assuming the invariability of G is at fault. It was there held that in such a view Kepler's laws are strained beyond their legitimate use.

A survey of previous researches on gravitation is then given and affords some slight information as to temperature effect; five cases are noticed.

In this connection it may be noticed that there are three classes of work, the results from which should be distinguished: (1) Change in temperature of both M and m (*indirectly* by Boys, Baily, von Sterneck); (2) Change in temperature of M only (*indirectly* by Mendenhall, *directly* in the present research); (3) Change in temperature of m only (*directly* by Poynting & Phillips).

In the present research a number of early experiments were made in a variety of ways. Finally, a form was adopted closely resembling the Cavendish experiments of Boys; that is to say, the small masses, m, m, were hung at different heights inside an exhausted chamber and were attracted by the large masses, M, M, hung at corresponding heights, but outside the chamber. The small masses were of silver, the large ones of lead. The

[1] Phil. trans., Royal soc., London, May 27, 1916, **216**: 349-392.

[2] *See* Science Abstracts, 1915, § 1628.

latter were electrically heated, their temperatures being read by mercury thermometers. The zero positions of the small suspended system were deduced by noting the turning points as read by a distant telescope and scale. Thus the relative gravitative effects with the large masses cold and hot are found by observing the shift in each case on rotating the large masses from the one attracting position to the other.

Elaborate precautions were taken to avoid various disturbances or spurious effects. Those dealt with are electrostatic, magnetic convection, radiometer pressure, occluded gases, damping, radiation pressure, conduction of heat, and displacements of apparatus. Taking all circumstances into consideration, a pressure of 14 mm. was held to be most satisfactory and was adopted in many of the later experiments. The results of the experiments with the final form of apparatus are summarized in the table [not reproduced here]. From this it is deduced, for the given temperature range of the larger masses (of about 47 kg. each) if a linear relation be assumed, that

$$f = G(1 + a\theta)Mm/d^2,$$

where a is a temperature coefficient of value $(+1.20 \pm 0.05) \times 10^{-5}$ per degree C.—*E. H. B[arton]*.

GRAVITATION AND TEMPERATURE.[3]

By J. L[ARMOR].

[*Reprinted from* Science Abstracts, Sect. A, Aug. 25, 1916, §861.]

As the outcome of a very delicate systematic series of experiments, it is announced by P. E. Shaw [see above] that when one large mass attracts a small one the gravitative force between them increases by about 1/500 as the temperature of the large mass rises from, say, 15° to 215°C.; that is, it increases by about 1.2×10^{-5} of itself per degree C. This seems to be a very startling result, at any rate if temperature is merely the expression of internal molecular motions, as indeed the experimenter seemed to admit.

By Newton's principle gravitation between masses must act reciprocally; the result, therefore, means that the astronomical mass of a body must increase with temperature by 1.2×10^{-5} of itself per degree C.

The pendulum experiments of Bessel and recent determinations by Eötvös seem to establish proportionality between gravitational mass and mass of inertia, irrespective of temperature, well beyond these limits. Thus inertia also would have to increase with temperature, and when a freely moving mass is becoming warmer its velocity must be diminishing, for its momentum must be conserved. A comet like Halley's is heated upon approach to the sun; thus it should suffer retardation in the approaching, and acceleration in the receding part of the orbit, enough, probably, to upset existing astronomical verifications.

Electrodynamic theory does establish unequivocally an increase of inertia of a body arising from gain (SE) of thermal or electric energy; but this is only of amount SE/c^2, where c is the velocity of radiation, and so is minute beyond detection. The question whether there is also an equivalent increase in gravitational mass evades discussion until some link connecting gravitative and electric forces has been established.—*E. H. B[arton]*.

[3] Review in Nature, London, June 15, 1916, **97**:321, of the paper by P. E. Shaw abstracted above.

ICE CRYSTALLIZATIONS FROM AQUEOUS SOLUTIONS.[1]

By R. HARTMANN.

[*Reprinted from* Science Abstracts, Sect. A, May 25, 1916, §628.]

The solutions contain cane sugar, glycerol, alcohol, NaBr, $MnSO_4$, NaOH, $FeCl_3$, or HCl, etc., in water, and are undercooled, with the two last-mentioned solvents to −38° and −40°C. The crystallites then separating are of four or five types: (a) The skeletons or nuclei are hexagonal or rectangular in outline, but the three or two (rectangle) axes cross in both cases at 60; (b) and (c) spherulites, radial or built up of plates; (d) feathery growths. With moderate undercooling (a) is obtained; (b) and (c) with heavy undercooling; (d) in very dilute solutions, whatever the cooling. In order to see whether the nuclei have all the same melting points, they were placed in water at −2° and then very slowly heated up, differences of 0.001 degree C. being observable; the melting points were always found normal. In the case of the two (a) types, the linear velocity of crystallization was further determined; no differences were observed. When, in the spontaneous crystallization, a nucleus happens to settle on the glass surface with its base, a hexagon seems to be formed; when with its triangular edge a rectangle is formed.—*H. B[orns]*.

THE KATA THERMOMETER AS A MEASURE OF THE EFFECT OF ATMOSPHERIC CONDITIONS ON BODILY COMFORT.[2]

By C.-E. A. WINSLOW.

[*Reprinted from* Science Abstracts, Sect. A, Aug. 25, 1916, § 862.]

The readings of an ordinary thermometer afford a poor indication of the degree of comfort felt by the average individual, who in addition to feeling the effects of temperature is also sensitive to air movements. To obtain a more satisfactory measure of comfort L. Hill devised the kata-thermometer outfit, which consists of two thermometers with large bulbs and stems graduated from 86° to 110°F., one to be read as a dry- and the other as a wet-bulb thermometer. The bulbs are heated to about 110°F., and then, while they are freely exposed, the time taken to fall from 100° to 90°F. is noted. The author has taken three series of readings with the apparatus under different circumstances. At the same time a band of observers estimated the degree of comfort of the conditions on an arbitrary scale of 1 to 5, in which 3 represented ideal conditions and 1 and 5 extremes of cold and warmth, respectively. The comparative instrumental and personal results are set out in tables and on a diagram. As a result it seems clear that the instrument is of great value in measuring the actual influence of air conditions on the body and is greatly superior to the ordinary thermometer for this purpose. The curves show that conditions of maximum comfort are represented by falling times, from 100° to 90° F., of 45–60 seconds for the wet-bulb, and 150–180 seconds for the dry-bulb.—*J. S. Di[nes]*.

BALL LIGHTNING ON PUY DE DÔME.[3]

By E. MATHIAS.

[*Reprinted from* Science Abstracts, Sect. A, Aug. 25, 1916, § 917.]

On April 15, 1916, the phenomenon of ball lightning was observed on three occasions—at $18^h\ 20^m$, $18^h\ 30^m$, and $18^h\ 50^m$—taking the form of a brilliant fireball with somewhat hazy contour, afterwards changing to an oval

[1] Zeitsch. f. Anorg. Chem., Aug. 6, 1914, **88**:128-132.
[2] Science, New York, May 19, 1916 (N. S.), **43**:716-719.
[3] Comptes rendus, Paris, Apr. 25, 1916, **162**:642.

with long axis horizontal. The discharges appeared sensibly stationary and lasted for some 2 or 3 seconds. Their color was white, tinted slightly mauve.—*C. P. B[utler]*.

CENTRAL OBSERVATORY OF MEXICO REMOVED.

Under date of October 5, 1916, we are informed by J. Covarrubias, chief of the Mexican Meteorological and Seismological Service, that the offices of the Central Meteorological-Magnetic Observatory have been removed from their former location in the City of México and are now in the city of Tacubaya, D. F., where they are located in the same building as that occupied by the "Direction of Geographical and Climatological Studies."

The geographical position of the Central Meteorological Observatory is now:

Height above sealevel, 2,308.5 meters (barometer cistern).

Longitude, $6^h\ 36^m\ 46.67^s$ west of Greenwich.

Latitude, 19° 24′ 17.9″ north.

CLEVELAND ABBE, 1838–1916.[1]

Professor Cleveland Abbe died about 4 a. m. on October 28, 1916. He had been in ill health since June 4, 1915, when he was stricken by a paralysis of the right side, from which he had largely recovered.[2] Since July, 1916, however, he had suffered from a malignant degeneration of a mole, which rapidly became so extensive as to prevent his resting comfortably in other than one position. The resultant irritation and great loss of sleep, together with the restricted diet imposed by the conditions of his paralysis, drained his strength. He returned from Portland, Me., where he had spent the summer of 1916, about the middle of September and in a greatly weakened condition. For a few days he enjoyed the freedom of his home, but soon retired to the room which he kept until the end. Mentally but little change was observable, and even on the afternoon of October 25 he dictated a letter to the Secretary of the Smithsonian concerning the details of publication of a paper on meteors.

Professor Abbe had not taken an active part in the Weather Bureau's work since June 4, 1915, being on leave or on furlough from that time until he resigned on August 3, 1916.

His death will awaken a keen sense of personal loss in the minds of his former colaborers. Professor Abbe was not only a tireless and prolific worker in behalf of the science and the public institution to which he dedicated the best years of his life, but he was also, in a very unusual degree, endowed with the faculty of communicating his enthusiasm to others and stimulating their efforts, a faculty that made itself felt both in personal intercourse and through his writings.

Born in New York City in 1838, he was graduated from the Free Academy (now the College of the City of New York) in 1857, and studied astronomy with F. Brünnow at Ann Arbor, 1858–60, and with B. A. Gould at Cambridge, 1860–64. From Cambridge he went to Russia, where he spent two years as a student and assistant at the Observatory of Pulkova, under the distinguished astronomer Otto Struve. On returning to the United States he was connected for a short time with the Naval Observatory, and was called thence to the directorship of the Cincinnati Observatory.

[1] A longer notice of Professor Abbe's work will appear in a later issue of the REVIEW.
[2] See MONTHLY WEATHER REVIEW, October, 1915, 43:507.

Professor Abbe's work at Cincinnati will always remain a landmark in the history of meteorology, as it was here that he organized, in 1869, with the assistance of the Cincinnati Chamber of Commerce and the Western Union Telegraph Company, a system of telegraphic weather reports, daily weather maps, and weather forecasts, the first regular undertaking of this kind in America and the prototype of the weather service now maintained by the Federal Government. Indeed, the object lesson afforded by Professor Abbe's undertaking was the strongest argument in behalf of the establishment of a national weather service in connection with the Signal Corps of the Army, a project urged upon Congress by Dr. I. A. Lapham and others and put into effect in the year 1870.

In January, 1871, Professor Abbe was appointed a civilian assistant in the office of the Chief Signal Officer, where he organized the forecast work and began preparing the tri-daily synopses and "probabilities" of the weather. In the same year he began and urged the collection of lines of leveling and in 1872, by laborious analysis, deduced the altitudes of the Signal Service barometers above sealevel. In 1873 he inaugurated the MONTHLY WEATHER REVIEW, and he prepared 22 of the first 60 numbers of this publication, which was then only a brief bulletin of current weather statistics. September 1, 1893, he was appointed editor of an enlarged publication bearing the same title, and under his direction it soon became one of the leading meteorological journals of the world.

It was largely owing to Professor Abbe's advice that General Myer, the Chief Signal Officer, sought the cooperation of foreign governments and of the International Meteorological Congress of 1873 in establishing the "Daily Bulletin of Simultaneous International Meteorological Observations," and Professor Abbe took a leading part in organizing this remarkable enterprise. Worldwide systems of observations continued to be one of the chief objects of his interest and advocacy throughout his career. He was also specially instrumental in the organization of the State weather services, the predecessors of the present climatological service of the Weather Bureau.

Professor Abbe never ceased to urge the importance of meteorological research, and he organized a branch of the central office, known at first informally and later officially as the "study room," in which many fruitful investigations were carried out. He himself set the example in this field of activity. He collected on cards about 11,000 titles of papers on meteorological and allied subjects at considerable expenditure of private means and personal effort. This collection was purchased in 1881 by the Signal Service and further enriched by very extensive contributions from all over the world, becoming international in importance and scope. The four parts, which began to appear as mimeographed pages in 1889, have never been continued and the remaining cards lie somewhat neglected in their dusty drawers in the Bureau library. This bibliography was classified to be of help to the workers in the "study room" and has proved invaluable, as far as available, to many others also.

He prepared for publication as supplements to annual reports of the Chief Signal Officer a "Treatise on Meteorological Apparatus and Methods" (1887) and "Preparatory Studies for Deductive Methods in Storm and Weather Prediction" (1889), and he laid English-speaking meteorologists throughout the world under a special obligation by collecting and translating the leading contributions to the subject of dynamic meteorology (pub-

lished by the Smithsonian Institution, 1877, 1891, and 1910). He also compiled a very comprehensive digest on the relations between climate and crops (published in part as Weather Bureau Bulletin 36). These notable works represent, however, only a small part of his scientific and literary activity. He was a voluminous contributor to scientific journals and books of reference, as well as to official publications. His scientific achievements were summarized by the president of the Royal Meteorological Society, when the Symons Memorial Gold Medal of that society was conferred on him in 1912, in the statement that he "has contributed to instrumental, statistical, dynamical, and thermodynamical meteorology, and forecasting," and "has, moreover, played throughout the part not only of an active contributor but also of a leader who drew others into the battle and pointed out the paths along which attacks might be successful."

Professor Abbe was one of the leading promoters of the introduction of standard time in this country, and was chairman of a committee of the American Metrological Society which urged this reform until it was finally adopted.

Thus passes an enthusiastic promoter of international good will; a devoted son of Science who appreciated and rejoiced in all advances in any of her many fields; a meteorologist of broad and deep scholarship, whose enthusiasm was an inspiration and encouragement to all about him and whose zeal did not flag in the very hour of death; a patriot whose lifelong service to the welfare of his country fully deserved the unusual courtesy shown by the half-masted flags on the Department of Agriculture and the Weather Bureau on the day he was laid to rest.

HENRIK MOHN, 1835-1916.

Henrik Mohn, the first professor of meteorology in the University of Christiania and director of the Norwegian Meteorological Institute from the time he founded it as an adjunct to the university in 1866 until he retired on September 1, 1913, died at the age of 81 on September 12, 1916.

Professor Mohn won the deserved and generous gratitude of the Norse fishermen by the establishment of the meteorological institute, which was made an independent Government institution in 1909. Before 1867 many hundred fishermen and their boats were lost almost yearly in storms that their experience was unable to foretell; to-day such losses are much rarer. He increased the efficiency of his meteorological service by also securing the cooperation of the captains of Norwegian fishermen in the Arctic as observers, an arctic weather service which culminated in the great international circumpolar cooperation of 1882–1883 which he brought about. Mohn himself led the Norwegian Arctic expedition of that campaign.

Professor Mohn was appointed a member of the International Meteorological Committee in 1873, and attended the first congress of official delegates which met in September of that year at Vienna. His subsequent regular attendance thus gave him a unique experience of international meteorological meetings.

Many contributions to meteorological science came from the hand of Professor Mohn. One of his earlier and more important works was written in collaboration with C. M. Guldberg in two parts, published in 1876 and 1880, treating of the Movements of the Atmosphere (Hvirvel Centrernes Theori). This was revised by the authors in 1883, and placed before American students in Professor Cleveland Abbe's third collection of translations called Mechanics of the Earth's Atmosphere (Washington, 1910). A text on the Elements of Meteorology reached a 5th edition in 1898 (Berlin) and was translated into many languages. His continued interest in circumpolar meteorological problems bore fruit more recently in the elaborate study to which he subjected the observations taken on board the *Fram*, 1893–1896. (See this REVIEW for September, 1905, **33**:401–2); and his discussion of the "Meteorology" of the scientific results of Amundsen's expedition to the South Pole (Kristiania, 1915).

An excellent portrait of Professor Mohn appeared as frontispiece to the "Geographen-Kalender, 11. Jahrgang, 1913," published by Justus Perthes (Gotha).—C. A., jr.

SECTION III.—FORECASTS.

FORECASTS AND WARNINGS, SEPTEMBER, 1916.

By EDWARD H. BOWIE, Supervising Forecaster.

[Dated: Weather Bureau, Washington, October 21, 1916.]

Over the Alaskan and Aleutian areas the pressure during the month averaged near the normal, with marked depressions over the Aleutian Islands on the 8th–9th, 14th–19th, 21st–22d, and 24th–26th, and marked excesses during the 1st–6th, 10th–12th, 20th, 23d, and 28th–30th, while over Alaska there were well-defined lows over the southern coast on the 2d–3d, 17th–19th, and 23d–26th, and over the interior on the 5th–9th, 16th–19th, and 22d–26th. The pressure averaged above the normal continuously during the month, save on the 21st, at Honolulu, Hawaii. Over the western portion of the North Atlantic as shown by the barometer readings from Bermuda, the pressure was above the normal almost continuously.

In the United States, the LOWS were mostly of northern origin. One made its first appearance north of the Great Lakes, five were of the Alberta, three of the northern Rocky Mountain, one of the South Pacific, and three of West Indian or tropical type. One of the latter did not, however, reach the American continent. The LOWS of September were not attended by violent winds. This was especially true of the tropical disturbances that reached the South Atlantic coast. One of these recurved east of the Bahamas and passed near Bermuda on the 23d, attended by destructive gales. The HIGHS during the month were eight in number, of which one made its first appearance north of the Great Lakes, two in Alberta, two in the northern Rocky Mountain region, and three off the North Pacific coast.

DISTRICT WARNINGS DURING SEPTEMBER.

Washington district.—The month opened with a tropical disturbance over the western Caribbean Sea and on the morning of the 1st the following advisory message was sent southern ports and distriuuted by wireless to vessels at sea:

> The tropical disturbance over the Caribbean Sea is apparently central off the east coast of Yucatan and moving westward. Thus far it has not been attended by dangerous winds, although winds of moderate gale force have prevailed during the last 24 hours in the Florida Straits, the southeast portion of the Gulf of Mexico, and the Yucatan Channel.

On the morning of the 2d, advisory information to the effect that

> The tropical disturbance has apparently crossed the Yucatan Peninsula to the Bay of Campeche, whence it will advance westward into Mexico and be dissipated,

was disseminated to southern ports and by wireless to vessels at sea.

On the morning of the 5th, northeast storm warnings were ordered for the South Atlantic coast between Savannah and Cape Hatteras and in the evening of the same day the display was extended northward to the Virginia capes. The necessity for the warnings arose from the presence of a disturbance of unknown intensity off the Georgia coast. The center of this disturbance passed inland near Wilmington, N. C., during the night of the 5th and thereafter lost intensity. Winds of moderate gale force off the South Atlantic coast attended this disturbance during its march northward. On the 11th information to the effect that there were indications of a disturbance east of the Bahamas was sent Atlantic and Gulf ports, and on the morning of the 12th northeast storm warnings were ordered for the Atlantic coast between the Virginia capes and Jupiter Inlet. The center of this disturbance crossed the coast line near Jacksonville during the night of the 12th and thence moved westward into Alabama. Winds of gale force prevailed off the South Atlantic coast while the disturbance was offshore.

On the evening of the 21st northwest storm warnings were displayed on western Lake Superior, at which time a disturbance of considerable intensity was immediately north of Minnesota, but no unusual winds attended this disturbance. On the 20th information was issued to the effect that there were indications of a disturbance east of the island of St. Kitts, West Indies, and on the 23d advices were issued to the effect that this disturbance was recurving east of the Bahamas and moving toward Bermuda. The storm passed northeastward near Bermuda during the night of the 23d and was there attended by destructive gales.

On the morning of the 27th southwest storm warnings were displayed on Lakes Huron, Erie, and Ontario, and strong southerly winds occurred on these lakes during the afternoon and night of this day. On the 30th southwest storm warnings were displayed on Lake Superior, northern Lake Michigan, and extreme northern Lake Huron, at a time when a disturbance of marked intensity was central over Manitoba, Canada. This disturbance moved northeastward toward Hudson Bay unattended by winds exceeding 40 miles an hour in the region where warnings were displayed.

Frost warnings were required on a number of days during the month, the principal issues being as follows: 1st and 2d, for exposed places in upper Michigan; 3d, for exposed places in northern New England, northern and central New York, and the cranberry marshes of New Jersey; 14th, for upper Michigan; 15th, for the upper lakes region, Indiana, western and central Ohio, and exposed places in Kentucky; 16th, interior of the Middle Atlantic States, the New England States, and the Ohio Valley; 17th, region of the Great Lakes, the upper Ohio Valley, and Indiana; 18th, region of the Great Lakes, the mountain districts of the Middle Atlantic States, the interior of New York, and northern New England; 19th, interior of New York and New England and the cranberry marshes of New Jersey; 21st, exposed places in upper Michigan; 23d, region of the Great Lakes; 24th, New England and the cranberry marshes of New Jersey; 25th, northern New England, northeastern New York, and the cranberry marshes of New Jersey; 29th and 30th, for the region of the Great Lakes, the Ohio Valley, and the Middle Atlantic and New England States.

Chicago district.—The frost-warning service throughout the month was the most important feature of the forecast

work in the Chicago district. On the 2d frost occurred in portions of the cranberry region of Wisconsin and quite generally throughout the northwestern portion of the State and in extreme northeast Minnesota. Warnings, however, were not sent in advance, because unsettled and showery weather was expected, but a rapid movement of a cold high area from Manitoba cleared away the clouds and caused a considerable fall in temperature. Very little damage, however, was reported.

The first high area that promised general frost appeared in British Columbia on the 13th, and warnings of frost were sent on that day to Montana, Wyoming, the Dakotas, northwestern Minnesota, and northwestern Nebraska; also an advisory message to the cranberry and tobacco interests of Wisconsin, as follows:

> A cool wave in the northwest will advance eastward, causing unseasonably low temperatures in Wisconsin Thursday night and Friday morning. Later advices will be sent to-morrow.

This advice gave these interests an additional day in which to prepare for the coming severe conditions, and was especially important to the tobacco growers. This cool wave moved eastward and southeastward over the entire district during the next two days, and frost warnings were issued for all regions threatened on the 14th and 15th. The ensuing temperatures were abnormally low for the season.

Another cool wave, but less general, immediately followed on the 17th and 18th, as an area of high pressure moved southeastward from the Canadian northwest. In this case the cold was not felt to any marked degree over Kansas, Missouri, and southern Illinois. The temperatures, however, were again unseasonably low in the western lake region and upper Mississippi valley, and warnings were issued well in advance.

On the 20th another high pressure area appeared in British Columbia which moved southeastward over the district. The frost was not of much importance except in the Northwestern States, and warnings were sent in advance for these sections. The temperature, moreover, was not nearly so low as in the preceding cool waves. This high area on the night of the 23d caused severe frost in the cranberry marshes of Wisconsin and warnings were issued to the various stations in the State on that day.

On the 27th another cool high area appeared in British Columbia and moved directly southeastward over the Chicago district. Warnings were issued on the 27th and 28th in advance of the wave; in fact, warnings were sent to all points in this district, except southeastern Illinois, which was not affected.

The cranberry growers of Wisconsin represent practically the only industry in this district that has full protection from frost, as water is available for flooding their marshes in advance. As a consequence, these growers suffered very little loss from frost.

The tobacco growers sometimes smudge, but, as a rule, they either cut the plants or take their chances with the frost, risking the subsequent injury and deterioration. In some cases this season the growers took the latter course, but even though severe injury occurred the money value of the crop is higher than in 1915. In cutting the plant before it is matured there is, of course, a loss also. It is estimated that the total loss to the Wisconsin tobacco growers this year either by frost or by lack of maturing because of cutting in anticipation of frost ranges from $500,000 to $1,000,000. However, the Weather Bureau did its full duty in issuing warnings in advance.

The Chicago office has the duty of issuing fire-weather warnings to the forested regions of the Northwest, but because of the favorable conditions prevailing there was practically no demand for this service during the month. Warnings, however, were issued on September 3 for Minnesota, South Dakota, and Wyoming for fresh to strong winds for the ensuing 24 hours. A message was also sent to the observer at Yellowstone Park on September 25, advising him of moderate winds, as he had telegraphed that a fire was raging in the park.

Long-range forecasts were sent to the observers at Springfield, Ill., and Helena, Mont., each for a week in advance, in connection with State fairs held in their cities. These forecasts were almost fully verified. The messages were as follows: Sent to Springfield, Ill., on September 19, "Fair weather with somewhat higher temperature indicated for balance of week." Sent to Helena, Mont., on September 25, "Conditions doubtful Tuesday, but probably mostly fair weather after that date and rather cool balance of week." The following message was also sent to the manager of the Missouri State Fair at Sedalia, Mo., on September 23, in response to his request of the same date: "Conditions favorable for showers Sunday and Monday, with somewhat higher temperature followed by fair and rather cool balance of week." However, because of slow moving conditions from the west, this forecast failed partly of verification.—*H. J. Cox.*

New Orleans district.—On the morning of September 12 an area of moderately high pressure, central over Colorado, was attended by low temperatures in Colorado, northern New Mexico, and western Kansas, with light frost in southern Colorado and northern New Mexico. Frost was predicted for extreme northwestern Oklahoma and the extreme northern portion of west Texas. In the ensuing 24 hours the area of high pressure weakened slightly in intensity and temperatures did not change materially, the minima being 50° or slightly below in the small area for which frost was forecast.

On September 14 a pronounced area of high pressure, central over northern Wyoming at 8 a. m., was moving southeastward, and frost was forecast for western Oklahoma and the Texas Panhandle. Temperatures of 40° and slightly higher were recorded on the morning of the 15th, but no frost was reported. As the possibility of frost occurrence was still evident on the 15th, frost was predicted for northern Oklahoma and extreme northwestern Arkansas, and temperatures in the forties were generally recorded on the 16th at stations in the area included in the warning. A further temperature fall was prevented by the rapid eastward movement of the high-pressure area.

On the 28th the pressure distribution in the western half of the country resembled that of September 14, but on the 14th the pressure diminished from the center of high pressure to the east Gulf coast, while on the 28th a shallow trough of low pressure extended from the Lake region southwestward over the lower Mississippi Valley to the west Gulf coast. Further, the temperature fall over the southern slope and Plains States was more uniform and decided on September 28 than on the 14th. On the 28th frost was forecast for the Texas Panhandle and northwestern and north-central Oklahoma. Light to heavy frosts occurred on the 29th, as predicted, and light frost also at Bentonville, Ark.

Frost warnings were issued on the 29th for Arkansas and eastern Oklahoma, and the warning was fully justified, frost being general in Arkansas on the 30th, with heavy frost at a few places, and frost temperatures occurred in eastern Oklahoma.

Small-craft warnings on the Texas coast were ordered September 28, and fresh northerly winds occurred that

afternoon and night. There were no higher wind velocities during the month and no storm warnings were issued.—*R. A. Dyke.*

Denver district.—The month was notably free from general or severe frosts. A warning of heavy frost for parts of eastern Colorado was issued on the 14th and warnings of light frost for parts of the district were issued on the 11th, 12th, 14th, 15th, 23d, 26th to 29th, inclusive.

On the morning of the 11th high pressure overlay Wyoming and the Great Basin, while low pressure prevailed in New Mexico and adjacent regions. Frost warnings were issued for Utah, northern Arizona, and northern and western Colorado. The front of the high-pressure area moved southeastward as expected, causing light frosts over the greater part of the area, with freezing temperatures in a few localities in the fruit districts of western Colorado. On the 12th warning of local frost in northern New Mexico was included in the regular forecast; it is probable that light frost occurred in the high districts. An area of high pressure overlay the northeastern Rocky Mountain slope on the morning of the 14th; its movement was southeastward, causing frosts in eastern Colorado and northeastern New Mexico, part of the area for which warnings had been issued. On the 23d frost was predicted for the high districts of Utah and was probably verified as the skies cleared. On the 26th a barometric trough extended from Arizona northeastward to Lake Superior, while high pressure overlay Oregon with the front of the high extending along the west side of the Continental Divide. Warnings of frost were issued for Utah, northern Arizona, western and northern Colorado, and northern New Mexico. Frosts occurred in parts of Utah, in northern Arizona, northwestern New Mexico, and locally in the fruit districts of western Colorado. In this case the warnings were somewhat premature, as the high did not continue southeastward but moved first north then east to Montana and thence southeastward on the east side of the Continental Divide. Warnings of frost were repeated on the 27th for Utah, Colorado, and northern New Mexico; they were fully verified in northeastern Colorado and locally in the rest of Colorado and Utah. Eastern Colorado, and northern and eastern New Mexico were still under the domination of the high on the morning of the 28th and warnings of frost were issued for these districts and were verified except in extreme southeastern New Mexico. The warning of the 29th for local frost in northern and eastern Colorado was verified only in a few localities, as the area came quickly under the influence of a northern low.—*F. H. Brandenburg.*

Portland district.—Normally quiet weather obtained during September over this district. The mean temperatures were above normal west of the Cascade Mountains and in northeastern Washington, and correspondingly below normal in the remainder of the district. Less than half of the usual rainfall occurred, and most of this fell during the first week. On this account there was a greater fire hazard than during August, and general fire weather warnings were issued on the 13th, 16th, and 20th, being disseminated by telegraph, telegram, and post card as usual. The forest fire patrols at the close of the month were still on duty in southern and eastern Oregon, eastern Washington, and Idaho.

No storm or small-craft warnings were issued, although they would have been justified on the 14th, when the verifying velocity was reached at Tatoosh Island, and again on the 26th, when similar conditions obtained at Tacoma. Winds of 26 to 36 miles from the northwest occurred on five days at the mouth of the Columbia River during afternoons following atmospheric conditions shown on the morning maps that would hardly have justified the sending out of small-craft warnings. These high winds were largely local in character, and it is believed no damage resulted.

Frost warnings were issued on six dates, of which three were verified, two were partially verified, and one was a failure. There were three dates on which light frost formed in limited areas for which no warning had been issued.

On the 1st low pressure obtained over the Pacific slope, with high pressure east of the Rocky Mountains. On the 2d the northwestern "low" crossed the northern Rockies and was followed to the northern California coast by a high-pressure area, causing rains throughout most of this district. Similar conditions prevailed on the 7th, 8th, and 9th; on the last date a high-pressure area began to overspread the north Pacific slope, and generally fair weather followed until a strong high-pressure area on the 24th reached the Oregon-northern-California coast, while the pressure over British Columbia was low, resulting in southerly winds and rains on the following two days. This HIGH subsequently moved northward and a portion moved inland, becoming the strong eastern HIGH of the latter part of the month, while generally fair weather prevailed over the Northwest.—*T. F. Drake.*

San Francisco district.—Light showers fell on the extreme north coast on the 1st and 2d, extending south of San Francisco Bay on the 3d; with this exception the weather was fair and pleasant until the 21st, when a trough developed rapidly over the interior of California and the Plateau, giving light but general rains in northern California and Nevada that night. Warnings were issued to the fruit sections at 11 a. m. on the 21st, and the drying fruit and raisins were covered, and but little if any damage resulted.

A low area moving eastward over Saskatchewan on the morning of the 29th caused the rapid development of a secondary depression over northern California, and rain warnings were issued at noon covering California and Nevada. These warnings were continued during the remainder of the month. Rain fell generally in the district, beginning during the night of the 29th–30th, and continuing. Drying fruit and raisins were covered, and but little damage resulted where wooden trays were used, but raisins on paper trays, unpicked grapes, and beans that had been cut were damaged.—*G. H. Willson.*

HURRICANE TRACKS, 1912–1915.

By Richard Hanson Weightman, Meteorologist.

[Dated: Weather Bureau, Washington, Nov. 1, 1916.]

Steps have been taken to extend the field of the Weather Bureau service in the West Indies and adjacent waters and at the same time to more completely equip the existing individual stations, as well as to secure two daily observations instead of the single daily report sent at present. This action was inaugurated primarily because the opening of the Panama Canal naturally resulted in an increased use of West Indian and contiguous waters as routes for trading vessels and, as a corollary, in the increased importance of meteorological observations and data pertaining to this area not only for climatological but for forecast purposes as well. The most important atmospheric phenomena with which commerce is concerned in these regions are the hurricanes or destructive storms which appear most frequently during the months of August, September, and October, about 90 per cent occurring in these months. In forecasting the move-

ment and intensity of a hurricane, two things are of foremost import: First, that there be available well-distributed observations daily, or twice daily, if possible, in order to enable the forecaster to locate accurately the center of the disturbance and, second, that there be at his disposal for ready references the previous history of all hurricanes, and more particularly accurate tracks of the same. It is only by an intensive study of the past behavior of such storms that a closer knowledge and better understanding of them may be gained, thereby better enabling the forecaster to anticipate their intensity and direction of movement. To this end it is the intention of the Bureau to bring up to date the charts given by Fassig in Weather Bureau Bulletin X, showing tracks of hurricanes for the period 1876 to 1911, inclusive.

Chart No. X (XLIV—121) shows the tracks of important hurricanes that have occurred in the West Indies and adjacent waters during the period 1912–1915, inclusive. The tracks for the present year will appear in the December, 1916, issue, and in subsequent years the tracks for the current year will appear in the December number of the REVIEW for that year. This will allow sufficient time to elapse between the occurrence of the storm and the publication of its track, so that all reports giving details of the hurricane may be received at the Central Office. It is believed that this scheme will result in the preservation of an accurate record of the tracks of these destructive storms of the Antilles that will be available to all persons and on which may be based any future study or discussion of the same.

To this end it is earnestly requested that any data bearing on the history of these disturbances be forwarded to the Central Office at Washington. Such information is particularly desired from vessels at sea.

FURTHER DATA ON THE TROPICAL STORM OF JULY 12-22, 1916.

By Prof. H. C. FRANKENFIELD.

[Dated: Weather Bureau, Washington, Oct. 13, 1916.]

The following report sheds some additional light on the behavior of the tropical storm of July 12–22, 1916, a brief account of which was published in the MONTHLY WEATHER REVIEW for that month. The report was prepared by Mr. T. Edelenborsch, second officer of the steamship *Ausable*, who made the observations, and is published in the MONTHLY WEATHER REVIEW in order that the record may be made as complete as possible.

The report has been edited slightly, and the millimetric barometer readings converted into inches:

SAN JUAN, P. R., *July 28, 1916.*

To the CHIEF, *U. S. Weather Bureau,*
Washington, D. C., U. S. A.

SIR: Sailed at 10:15 a. m., July 16, 1916, from Norfolk, Va., bound for Porto Rico to load bunker coal.

Met at first fresh southeasterly breezes with cloudy sky (the greater part cumulus). At 8 p. m. the wind become more southerly and during the watch from midnight till 4 a. m. it was calm with clear sky. In the forenoon of the 17th the wind became more southerly, with a force of 2 (Beaufort scale). It now became cloudy (cumulus and cumulo-nimbus). The barometer was observed continually, as we had read in the newspapers about a hurricane that had passed Porto Rico on July 12.

The average barometric pressure was 30.04 inches, and the temperatures were not out of the ordinary.

In the afternoon of the 17th the wind increased and shifted after 4 p. m. to east-southeast, increasing until a force of 6 was reached, while the sea became more turbulent. The barometer fell a little to 29.92 inches. The daily amplitude was normal. During the watch from midnight till 4 a. m. of the 18th the wind shifted to northeast, increasing to a force of 7, the barometer fell to 29.90 inches, the sea became more turbulent. A swell started from south-southeast with passing showers. After 4 a. m. it started to rain, while the wind increased after 8 a. m. to a force of 8 and 9. The barometer at 8 a. m. read 29.86 inches, and the wind shifted to north-northeast. The barometer fell to 29.76 inches at 11 a. m. and to 29.72 at noon, and the sea was very high with overcast sky. In the afternoon the wind shifted to east-northeast, increasing to a force of 10, with heavy rainfall, dirty sky, and a very high and turbulent sea. At 1 p. m. the barometer read 29.65 inches, at 2 p. m. 29.61 inches, and at 4 p. m. 29.53 inches. During the watch from 4 p. m. to 8 p. m. the wind became more easterly, and at 8 p. m. the barometer read 29.49 inches. After 8 p. m. the wind became more east-southeasterly with a force of 10; very high and turbulent sea, heavy rain squalls with hard sky. The barometer at midnight read 29.28 inches. After this the wind increased to a force of 11 and 12, while the barometer was falling rapidly. The wind continued east-southeasterly until the ship was in the center of the hurricane, when the barometer read 28.94 inches. Heavy rain squalls. Here the seas came from all directions. About 2 a. m. of the 19th the wind went down to force 5 and hauled to southwest through south, increasing from 3 a. m.; the rain stopped and the sky cleared a little. During the heaviest wind there was a high, regular sea from east-southeast; nearing the center it became irregular, but all the time, and throughout the entire storm field, we experienced a high swell from south-southeast. After 4 a. m. the wind became more southwesterly and decreased a little. Very heavy rain squalls with phenomenal sea and overcast sky. The barometer rose, and at 8 a. m. read 29.41 inches. During the whole day the wind blew principally from southwest with a force of 9. The barometer rose continually and at 11 a. m. read 29.57 inches, at noon 29.61 inches, at 4 p. m. 29.68 inches, at 8 p. m. 29.78 inches, and at midnight 29.82 inches. There was a very high and irregular sea with high swell, and further very heavy rain squalls with overcast sky. On the following day (20th) the barometer rose steadily, the wind decreased and became more westerly, and on the morning of the 21st shifted gradually to the east, after which the usual trade wind was met. During July 20 there were still heavy rain squalls with more or less covered sky and southwest and northeast swells. When the sky cleared in the afternoon of the 20th cirrus appeared with the radiation point bearing northwest, on the morning of the 21st north, and during the remainder of the day and also on the 22d north-northeast and northeast, the sky becoming free of cirrus during the afternoon of the 22d.

Barometer readings on July 20 were as follows: 4 a. m. 29.95 inches, 5 a. m. 29.96 inches, 8 a. m. 30.04 inches, noon 30.08 inches, 4 p. m. 30.08 inches, 8 p. m. 30.12 inches, midnight 30.16 inches.

Owing to the high sea and swell it was impossible to make any speed, and we met the hurricane at about 32° 30′ north latitude and 73° west longitude.

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, SEPTEMBER, 1916.

By ALFRED J. HENRY, Professor in Charge.

[Dated: Weather Bureau, Washington, Oct. 26, 1916.]

There was a rather marked absence of floods in all of the larger rivers of the United States during September, 1916. In the lower Rio Grande flood stage was reached on the 14th, Rio Grande City, Tex., but evidently the flood was confined to the extreme lower reaches of the stream, since the river at Eagle Pass, Tex., the next station upstream was below flood stage throughout the month.

Freshet stages prevailed on the Nueces River on the 15th, evidently due to local rains in the watershed. The rivers of South Carolina were near flood stage during the early days of the month, but fell steadily thereafter.

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

SNOW DENSITIES IN THE SIERRA NEVADA.

By HENRY F. ALCIATORE, Meteorologist.

[Dated: Weather Bureau Office, Reno, Nev., Aug. 10, 1916.]

Students of meteorology can not but be impressed by the paucity of information that characterizes most of the present-day textbooks as to the density of snow and its underlying causes, and we may say, in passing, that some of the information contained therein is of doubtful value, if not actually misleading. For instance, in one of the latest works on meteorology (published in 1912) the author states that: "It requires from 6 to 30 inches of snow to make an inch of water, depending on the lightness of the snow; the average value, however, is about 10."

Now, in terms of density this means that one kind of snow may have a density of 17 per cent and another kind 3 per cent. As this writer does not tell his readers whether freshly fallen or old snow is meant, that statement leaves much to be desired as to accuracy and completeness. As a matter of fact, Ward [1] has found densities of 0.008 (March, 1876) and 0.020 (December, 1874), and Chassant [2] mentions one of 0.024 (L'Hérault, March 1887); Mougin and Bernard [2] (July, 1903) found a density of 0.344; all of the above values are for fresh snow. As to old snow, densities of 0.450 are very common in the spring; Cole,[3] of the United States Weather Bureau, found a density of more than 80 per cent near the ground in a deep snow cover in the Sierras. As a rule fresh snow is less dense than old snow, but exceptions are met with occasionally. Schreiber [4] made some measurements at Potsdam in 1896 with the following results:

Results of measurements of snow densities by Schreiber at Potsdam-Berlin, 1896.

Dates.	Old snow.		New snow.	
	Depth.	Density.	Depth.	Density.
	Mm.		*Mm.*	
Jan. 9	39	0.27	11	0.04
Jan. 16	71	0.16	31	0.18
Feb. 15	78	0.07	78	0.07

"A simple consideration of the difference between fresh and old snow," says Bracke,[4] "shows that temperature, humidity, direction of the wind, fogs, and clouds, are many factors which intervene to produce variations in the physical state of a snow cover; it is of the greatest importance to state the condition of the weather when making measurements."

In the spring of 1916 a series of snow surveys was made by the United States Weather Bureau in the Tahoe, Carson, and Walker watersheds, in cooperation with the University of Nevada. The several snow courses lay within a quadrangle about 58 miles long, by 45 wide, with its northern edge in latitude 38° 58′ N., and its eastern edge in longitude 119° 25′ W. According to A. H. Palmer,[5] this includes the region of heaviest snowfall in the United States. In all, 11 courses were laid out, in each of which 39 to 40 measurements, 50 feet apart, were made with a snow sampler and spring balance devised several years ago by Dr. J. E. Church, jr., meteorologist of the University of Nevada. The depth of the snow cover, in inches, was measured with the sampler tube, while the water content was obtained by weighing the tube and its core of snow with the spring balance, the dial of which gives directly the water equivalent of the snow in inches. The mean density of the snow is obtained by dividing the water content by the depth of the snow.

The courses at Meyers Station, Cal., Genoa Summit, Nev., and Freels Peak, Cal., were surveyed on March 17 and 18, and April 16, respectively; those at Grass Lake, Blue Lakes, Burnside Lake, and Williams, Cal., on March 17, 24, and 26, respectively; and those at Pickle Meadow, Willow Flat, Cinque Mountain, and Big Meadow, Cal., on April 4, 5, 8, and 9, respectively. This work was not undertaken by the Government and the university for experimental purposes, but with the view of establishing a basis for the correlation of snowfall and run-off in these watersheds, and estimating the available water supply stored in the snow.

To ranchers, hydroelectric engineers, and managers of municipal water plants and reclamation projects in Nevada, each season's available run-off from Lake Tahoe (whose sole outlet is the Truckee River) is of great importance. How the snowfall and run-off in the Lake Tahoe watershed have been correlated, and forecasts of the probable maximum summer level in that lake made possible thereby by the writer, have been explained in another paper.[6] Here we shall confine ourselves to a considera-

[1] *Wengler, Fritz.* Spezifische Dichte des Schnees. Berlin, 1914. p. 14.
[2] *Bracke, A.* La densité de la neige. Bruxelles, 1906. pp. 5, 18.
[3] In an unpublished MS. report of 1913, in Weather Bureau files.
[4] Bracke, op. cit., p. 9, 23.
[5] This REVIEW, May, 1915, 43:217.
[6] *Alciatore, Henry F.* A method of forecasting the maximum summer level in Lake Tahoe ... MONTHLY WEATHER REVIEW, July, 1915, 44:407-9.

tion of the various relationships between depth and mean density; altitude and depth; age and mean density; and pressure and density of snow covers.

Relation between depth and density.

Table 1 has been prepared to show the relationship between the mean density and depth of the several snow covers in the Sierra Nevada Mountains. The 438 measurements made in that region have been tabulated in numerical order, according to depths, which are given for each half inch, regardless of geographical location, topography, altitude, or physical condition of the snow. (Wherever two or more measurements were made at the same depth, the number of such measurements is indicated by a small figure prefixed to the depths, but the density given is the arithmetic mean of all the densities for the given depth.)

In Table 2 are given the mean densities for snow layers of different depths arranged in steps of 10 inches progressively in the order of total depth of snow cover for the same region.

As we glance down the columns of Table 1, the first thing that strikes the eye is that the densities are remarkably uniform; in fact, 90 per cent of them fall between 0.40 and 0.49; in 13 exceptional cases, the densities vary from 0.332 to 0.399, and in 5 others, from 0.501 to 0.538. The highest individual mean density, **0.538**, occurred in a layer of total depth of 48.5 inches, while the lowest, **0.332**, was found in a layer having a total depth of 142 inches. These abnormalities are so interesting that we consider it worth while to give them in tabular form (Table 3), together with depths, watersheds, elevations, and the dates of surveys. They have occurred in all basins, and at different depths, altitudes, and dates.

It is interesting to note that at equal depths, the same mean densities have been observed at points a considerable distance from each other and of different elevations. For example: At a depth of 54.5 inches, a density of 0.455 was found at Meyers Station, Tahoe Basin, elevation, 7,000 feet, March 17; and also at Freels Peak, same basin, *one month later*, at an elevation of 8,500 feet.

TABLE 1.—*Depths and average densities of snow cover in the Tahoe, Carson, and Walker basins, March–April, 1916.*

Number of measurements.	Depth.	Density.	Number of measurements.	Depth.	Density.
	Inches.			*Inches.*	
	12.5	0.352	3	40.5	0.452
	17.0	.394	4	41.0	.498
	22.0	.468	3	41.5	.452
3	23.0	.448	3	42.0	.460
	23.5	.472	3	42.5	.482
2	24.0	.458	3	43.0	.474
2	27.0	.459		43.5	.487
	28.0	.479	4	44.0	.489
2	29.5	.458	3	44.5	.472
	30.0	.477	3	45.0	.498
	30.5	0.456		45.5	0.446
	32.0	.484	3	46.0	.430
3	32.5	.455	2	47.0	.436
2	33.5	.481	2	47.5	.413
3	34.0	.418	5	48.0	.448
3	34.5	.487		48.5	.538
2	35.0	.480	2	49.0	.437
4	35.5	.423	2	49.5	.463
	36.5	.468		50.0	.456
6	37.5	.444			
8	38.0	.476	3	50.5	0.463
3	39.5	.478	5	52.0	.444
5	40.0	.462	7	53.0	.462

TABLE 1.—*Depths and average densities of snow cover in the Tahoe, Carson, and Walker basins, March–April, 1916*—Continued.

Number of measurements.	Depth.	Density.	Number of measurements.	Depth.	Density.
	Inches.			*Inches.*	
4	53.5	0.430		98.5	0.469
7	54.0	.452	2	99.0	.414
2	54.5	.455		99.5	.501
2	55.0	.451			
			2	100.0	0.449
3	55.5	0.425	3	101.0	.459
4	56.0	.416	2	103.0	.423
3	56.5	.480	2	104.0	.408
3	57.0	.439		104.5	.428
3	58.0	.412	4	105.0	.457
4	58.5	.455		107.0	.447
2	59.0	.509	3	108.0	.409
2	59.5	.454	3	109.0	.399
2	60.0	.403		109.5	.447
			4	110.0	.425
3	60.5	0.469			
5	61.0	.436	3	112.5	0.450
3	61.5	.444	2	113.0	.474
2	62.0	.445		114.5	.366
2	62.5	.461		115.0	.418
3	63.0	.498		115.5	.448
4	63.5	.454	2	116.0	.444
4	64.0	.414	3	118.0	.407
	64.5	.462		118.5	.449
6	65.0	.438		119.0	.469
			4	120.0	.420
	65.5	0.406			
4	66.0	.430		121.0	0.464
2	66.5	.417		121.5	.438
3	67.0	.441		122.0	.468
6	67.5	.430		122.5	.460
8	68.0	.421		123.5	.429
4	69.0	.455		125.5	.436
2	69.5	.445		126.5	.427
5	70.0	.413	4	127.0	.457
				127.5	.456
3	71.0	0.431	2	128.0	.391
3	71.5	.421			
	73.0	.432		128.5	0.424
4	73.5	.435		129.0	.467
4	74.0	.416	2	131.0	.441
	74.5	.498	3	132.0	.415
	75.5	.403		133.0	.458
	76.0	.438	2	134.0	.402
5	78.0	.447		135.0	.416
	78.5	.493		137.0	.425
			3	138.0	.430
	81.0	0.430	2	139.0	.452
	81.5	.474			
2	82.0	.438		140.0	0.444
	82.5	.502		142.0	.332
	83.0	.447		142.5	.437
	83.5	.436		144.5	.436
7	84.0	.456		148.0	.390
2	84.5	.405	3	149.0	.404
4	85.0	.454		149.5	.401
	85.5	.416	2	150.0	.437
4	86.0	0.444	2	151.0	0.385
	86.5	.506		152.0	.397
3	87.0	.421	3	153.0	.422
2	88.0	.443		154.0	.362
2	89.0	.393	2	156.0	.437
2	89.5	.472		157.0	.417
2	90.0	.424		158.0	.423
2	91.0	.465		159.0	.436
2	92.0	.485		159.5	.404
2	92.5	.445			
				160.0	0.356
2	93.0	0.480		163.0	.420
2	94.0	.466		165.0	.439
3	95.0	.460		166.0	.473
2	96.0	.448		168.0	.384
	96.5	.492		170.0	.412
6	97.0	.446		172.0	.415
	97.5	.431		172.5	.417
4	98.0	.451		173.0	.418

TABLE 2.—*Depth and average density of snow layers in the Tahoe, Carson, and Walker basins, March–April, 1916 (compiled from Table 1).*

Depth.	Average density.	Depth.	Average density.
Inches.		*Inches.*	
10–20	0.373	100–110	0.430
20–30	0.465	110–120	0.434
30–40	0.462	120–130	0.443
40–50	0.465	130–140	0.431
50–60	0.450	140–150	0.405
60–70	0.439	150–160	0.404
70–80	0.441	160–170	0.426
80–90	0.445	170–173	0.417
90–100	0.460		

TABLE 3.—*Exceptionally high and low average snow densities in the Tahoe, Carson, and Walker watersheds, March–April, 1916.*

Density.	Depth.	Watershed.	Elevation.	Date of survey.
Low.				
	Inches.		*Feet.*	
0.332	142.0	Carson	8,000	Mar. 24.
0.352	12.5	Walker	7,950	Apr. 5.
0.356	160.0	...do	8,800	Apr. 8.
0.362	154.0	Carson	8,000	Mar. 24.
0.366	114.5	Walker	7,050	Apr. 5.
0.384	168.0	...do	8,800	Apr. 8.
0.385	151.0	Carson	8,000	Mar. 24.
0.390	148.0	...do	8,000	Do.
0.391	128.0	Walker	8,800	Apr. 8.
0.393	89.0	Carson	7,500	Mar. 17 and 26.
0.394	17.0	Tahoe	8,500	Apr. 16.
0.397	152.0	Carson	8,000	Mar. 24.
0.399	109.0	...do	8,000	Mar. 24 and 26.
High.				
0.501	99.5	Walker	7,525	Apr. 9.
0.502	82.5	...do	7,280	Apr. 4.
0.506	86.5	...do	7,280	Do.
0.509	59.0	Tahoe	7,000	Mar. 17.
0.538	48.5	Walker	7,280	Apr. 4.

Altitude and depth of snow cover.

As to the relationship between altitude and the depth of the snow cover, we give in Table 4 the names of the "courses" and watersheds, and the elevations and average depths of snow cover for the 11 courses surveyed in 1916, with dates.

TABLE 4.—*Altitude and depth of snow cover in the Tahoe, Carson, and Walker watersheds, March–April, 1916.*

Name of course.	Watershed.	Elevation.	Average depth of snow cover.	Date of survey.
		Feet.	*Inches.*	
Meyers Station	Tahoe	7,000	64	Mar. 17
Pickle Meadow	Walker	7,200 7,750	43	Apr. 4
Grass Lake	Carson	7,500	65	Mar. 17
Big Meadow	Walker	7,525	78	Apr. 9
Willow Flat	...do	7,900 8,025	50	Apr. 5
Genoa Summit	Tahoe	8,000	55	Mar. 18
Burnside Lake	Carson	8,000	94	Mar. 26
Williams	...do	8,000	88	Do.
Blue Lakes	...do	8,000	139	Mar. 24
Freel Peak	Tahoe	8,500	44	Apr. 16
Cinque Mountain	Walker	8,800 9,050	126	Apr. 8

The greatest average depth was found at Blue Lakes, at an altitude of 8,000 feet, March 24, and the least at Pickle Meadow, elevation 7,200–7,750 feet, April 4, and the depths measured 139 and 42 inches, respectively. It is evident that the several snow covers did not vary directly as to depth either with altitude or with age. This is not unusual.

Age of snow cover in relation to density.

The dates of surveys, watersheds, elevations, and average densities for 11 courses are given in Table 5.

TABLE 5.—*Increase in average density of snow with age in the Tahoe, Carson, and Walker watersheds, March–April, 1916.*

Date of survey.	Watershed.	Elevation.	Average density.
		Feet.	
Mar. 17	Carson	7,500	0.414
Do	Tahoe	7,000	0.427
Mar. 18	...do	8,000	0.440
Mar. 24	Carson	8,000	0.410
Mar. 26	...do	8,000	0.438
Do	...do	8,000	0.444
Average for surveys made in March			0.429
Apr. 4	Walker	72–7,750	0.490
Apr. 5	...do	70–8,025	0.456
Apr. 8	...do	88–9,050	0.436
Apr. 9	...do	7,525	0.462
Apr. 16	Tahoe	8,500	0.472
Average for surveys made in April			0.463

The later surveys, as might be expected, show a greater average density in the snow cover. The last general fall of snow for the season of 1916, a light one, occurred in all basins about March 5.

Relation between pressure and density.

We shall now briefly consider the relationship between pressure and density. For obvious reasons this phase of the subject is approached with hesitancy, for the pressure function is a complex one, and the evidence adduced by various investigators as to the effect of pressure on density is conflicting. Attempts have been made by Abe, Wengler,[7] and others to express this relation in concrete mathematical form, but so far as we know no formula of general application to practical problems has yet been worked out. In working out a logarithmic formula, Abe started out with the assumption that "the density of snow increases in proportion to the pressure." This may be well enough when we are dealing with a per fec ly homogeneous mass of snow, but not otherwise. Abe's deduc d densities differed materially from the observed ones. In one instance, where the snow cover was 65 centimeters in depth and the densities were given for seven layers, the differences between the observed and computed densities ranged from +0.020 to −0.070.

Wengler[8] gives the depths and densities shown in Table 6, quoted from a report by Defant, who made some density measurements on the Goldberg glacier in August, 1908.

TABLE 6.—*Depth and density of snow on Goldberg Glacier, August, 1908.*

Depth.	Density. Mean.	Density. Maximum.	Density. Minimum.	Depth.	Density. Mean.	Density. Maximum.	Density. Minimum.
Cm.				*Cm.*			
12.5	0.280	0.324	0.205	187.5	0.542	0.647	0.493
37.5	0.388	0.500	0.320	212.5	0.556	0.626	0.501
62.5	0.515	0.579	0.423	237.5	0.556	0.649	0.481
87.5	0.632	0.690	0.518	262.5	0.583	0.650	0.537
112.5	0.608	0.797	0.516	287.5	0.578	0.599	0.562
137.5	0.536	0.606	0.475	312.5	0.607	0.669	0.573
162.5	0.534	0.637	0.512				

[7] *Wengler, F.*, op. cit., p. 70–79.
[8] Op. cit., p. 69.

A very significant feature of Table 6 is that the greatest average density (six measurements were made at each level) did not occur in the lowest layer, but at depth 87.5cms. (fourth layer). Defant[9] explains this abnormality as follows:

> After a heavy snowfall there fell an intensive rain, which, however, had only soaked in to the upper *layers*, which lay within depth of 87.5 centimeters; by recurrence of frost, a rough ice crust, 10 centimeters thick, had formed upon which the new snow rested; under that crust was found a real glacier snow extending into greater depths into glacial ice, whose density was found to be 0.85.

It seems to us that the possible and more than probable occurrence of such abnormal strata every season in any watershed where the winters are long, the temperatures alternately high and low, and rains alternate with snows, must necessarily introduce factors which make such formulæ as that proposed by Abe[10] of doubtful value in the solving of practical problems in snow density.

The abnormality referred to above is not an isolated one. Schreiber[11] made some measurements in the region of the Fichtelberg (March, 1904), the results of which are given in Table 7. The total depth of the snow cover was 280 centimeters, and four measurements were made, in layers each 50 centimeters thick.

TABLE 7.—*Depth and density of snow cover in the Fichtelberg, March, 1904.*

Depth.	Density.	Depth.	Density.
Centimeters.		*Centimeters.*	
50	0.51	150	0.53
100	.45	200	.45

Here we have another instance where the greatest density was not found in the layer where the pressure was greatest. Indeed, at depths of 100 and 200 centimeters the densities were the same.

Bracke,[12] in his paper gives some measurements of interest, from which we have prepared Table 8.

TABLE 8.—*Depth and density of snow.* (*Bracke.*)

Depth.	Density.	Depth.	Density.
Millimeters.		*Millimeters.*	
0-10	0.136	401-10	0.156
41-50	.190	501-10	.287
91-100	.128	601-10	.261
151-160	.143	711-20	.227
191-200	.202	1,500	.362
241-50	.136	2,000	.380
301-10	.185		

It will be seen that while the density at depth 41–50 mm. was 0.190, at depth 401–10 mm. it was only 0.156, yet the pressure at the latter station no doubt was considerably greater.

J. E. Church,[13] of the University of Nevada, under whose supervision thousands of snow measurements have been made in the Sierras during the past six years, has published some of his results, extracts from which are presented in Table 9 of this paper.

TABLE 9.—*Table of snow densities for estimating the water content of snow without a snow sampler. Church.*[13]

April and May in—	Depth.	Density.	Elevation.
	Inches.	*Per cent.*	*Feet.*
Open country	3.2	39.5	
	9.6	37.1	
	18.8	*44.0*	
	29.5	44.7	
	36.5	*39.9*	
Forested country. (Dense forest)	3.3	37.2	
	10.2	*45.6*	
	19.4	40.5	
	28.9	34.1	5,000 to 7,000
	37.5	42.1	
	48.1	42.8	
	59.4	40.3	
	69.5	37.5	
	78.6	37.5	
	89.6	*40.2*	
	97.4	43.8	
Open country	2.1	42.0	
	10.2	33.6	
	19.9	33.0	
	30.2	32.2	
	39.9	41.8	
	50.5	43.2	
	59.9	47.2	
	70.4	44.8	
	80.3	46.2	
	89.5	45.6	9,000 to 10,800
	100.3	*48.5*	
	110.1	47.6	
	118.8	47.9	
	129.8	50.4	
	137.3	49.7	
	149.4	49.0	
	160.5	48.5	
	167.6	*47.8*	
	186.5	52.0	

The title of Table 9 is that used by Dr. Church himself. A comparison of the 3d and 5th, 7th and 15th, and 27th and 34th entries (italicized) in the density column of that table shows that both in the open and the forested areas, and at low and high elevations, wide departures from the rule as to increase of density with increase of pressure have occurred in the Sierra Nevadas.

In order to demonstrate that no relationship between pressure and density may be assumed in the ordinary, or nonhomogeneous, snow cover found in nature, such as that upon which Abe[14] bases the formula $D.dz=dp$, we have computed the pressures by layers for each of the twelve successive layers of the cylindrical column of snow of 1 square-foot base cut out of the snow cover on Goldberg glacier measured by Defant in August, 1908, from which the total pressure on the top surface of the 13th or bottom layer has been deduced. The results are given in Table 10, in which the densities are those taken from the second column of Table 6. It is obvious that here "pressure" means the weight of the snow itself, exclusive of atmospheric pressure. Hence, if we make p equal to W we have

$$W=A\times H\times D\times 62.425 \text{ lbs.}$$

where W is the weight in pounds; A, cross sectional area of column in feet; D, the density; and 62.425, the weight of a cubic foot of water at 39.2° F.

[9] *Wengler*, op. cit., p. 70.
[10] *Wengler*, op. cit., p. 74–75.
[11] *Bracke, A.*, op. cit., p. 6.
[12] *Bracke, A.*, op. cit., p. 25.
[13] See an undated blue print issued by the University of Nevada, Reno, Nev., presenting a "Table of Snow Densities."
[14] *Wengler, F.*, op. cit., pp. 75–76.

TABLE 10.—*Pressure and density of a cylindrical column of snow, Goldberg glacier, August, 1908.*

[Cross sectional area=1 square foot.]

Layer.	Depth.		Density.	Pressure.
	Cm.	*Feet.*		*Pounds.*
1	12.5	0.41	0.280	7.16
2	37.5	1.23	0.388	27.62
3	62.5	2.05	0.515	53.38
4	87.5	2.87	0.632	85.73
5	112.5	3.69	0.608	116.85
6	137.5	4.51	0.536	144.29
7	162.5	5.33	0.534	171.63
8	187.5	6.15	0.542	199.37
9	219.5	6.97	0.556	227.83
10	237.5	7.79	0.556	256.29
11	262.5	8.61	0.583	286.18
12	287.5	9.43	0.578	315.72
Bottom layer	312.5	10.25	0.607	....

It is clear that despite the great pressure—more than 315 pounds per square foot—exerted by the overlying layers of snow upon the bottom layer, its density, 0.607, is less than that of the fourth and fifth layers, upon which the pressures were only 53 and 86 pounds, respectively.

It seems to us that any attempt to estimate the density of the lowest layers of a snow cover of some depth at the close of winter from measurements of the *pressure* exerted by the snow in the top layer is about as safe a proceeding as that of estimating the density of the lowest layers of a sawdust cover in a sawmill where white pine, gum, mahogany, and teak lumber is milled indiscriminately, by computing the pressure of the top layer and deducing therefrom the probable density of the underlying layers.

CONCLUSIONS.

A careful and unbiased analysis of the foregoing data will, we believe, warrant the following conclusions:

1. That the average density of a snow cover at or near the close of winter depends primarily, if not chiefly, on the various atmospheric conditions (particularly as to freezes and rains) under which the several layers have been deposited, and the age of the snow cover.

2. That the density of snow in late spring does not vary directly as the depth, pressure, or altitude of the cover.

3. That in a given snow cover strata having abnormally high or low densities (relatively to the average density of the whole cover) may occur in open as well as forested areas, and in the upper, middle, and lower layers.

4. That to deduce, by formula, the density of the lowest layers of a snow cover from measurements of the depth or pressure of its top layer is not a practical proposition, except, perhaps, in the case of a homogeneous snow cover.

My colleagues of the Reno station, Messrs. W. Bailey and O. H. Hammonds, whose kind assistance[15] in the proof reading of the tables and the translating of articles by foreign writers is gratefully acknowledged, concur as to the conclusions reached by the writer of this paper.

MEAN LAKE LEVELS DURING SEPTEMBER, 1916.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Oct. 5, 1916.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during September, 1916:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	603.88	580.76	572.33	246.69
Above or below—				
Mean stage of August, 1916	+0.15	−0.28	−0.47	−0.67
Mean stage of September, 1915	+1.48	+0.82	+0.13	+1.24
Average stage for September, last 10 years	+1.27	+0.10	−0.02	+0.59
Highest recorded September stage	−0.20	−2.67	−1.61	−0.92
Lowest recorded September stage	+2.39	+1.10	+1.05	+2.69
Average relation of the September level to:				
August level	±0.0	−0.2	−0.3	−0.4
October level	±0.0	+0.2	+0.2	+0.4

[15] The author further wishes to acknowledge the assistance received from his wife while preparing and revising this paper.

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR SEPTEMBER, 1916.

By W. J. HUMPHREYS, Professor in Charge.

[Dated: Weather Bureau, Washington, D. C., Nov. 1, 1916.]

TABLE 1.—*Noninstrumental earthquake reports, September, 1916.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
	H. m.		° ′	° ′			*M. s.*			
1	2 30	Spreckels	36 35	121 38		1	0 1	None		Spreckels Sugar Co.
1	12 20	Victorville	34 32	117 18	3	1	1	None		J. M. Henry.
2	7 00	Victorville	34 32	117 18	4	3	3	None	Awakened some people	J. M. Henry.
6	19 40	Spreckels	36 35	121 38		3	3	Rattling		Spreckel Sugar Co.
8	16 50	Spreckels	36 35	121 38		1		None		Spreckel Sugar Co.
28	3 45	Hollister	36 50	121 20		1				J. N. Thompson.
29	12 20	Calexico	32 39	115 29	3	1				J. R. Spencer.
30	2 11	Arrowhead Springs	34 15	117 16	2	1	1	None		C. P. Dandy.
	2 11	Barrett	32 40	116 40	3	1				L. P. Beidleman.
	2 11	Beaumont	33 55	117 00	4	1	3	None		K. R. Smart.
	2 11	Cahuilla	33 32	116 43	4	2	20	Rumbling	Shook buildings	Dr. W. M. Shawk.
	2 11	Coachella	33 40	116 10	5	2	30	Rumbling		Frank McCarrol.
	2 11	El Cajon	32 48	116 58	4	1	30	Rumbling		H. H. Kessler.
	2 11	Julian	33 05	116 37	5	1	15	Rumbling		J. H. L. Vogt.
	2 11	Mecca	33 34	116 05	4	1			Shook houses	E. A. Palmer.
	2 11	Mesa Grande	33 11	116 42	4	1	5	Rattling		E. H. Davis.
	2 11	Nellie	33 22	116 52	4-5	1		None		Esther Hewlett.
	2 11	Palm Springs Station	33 49	116 37	5	1	1 00	Rumbling		H. C. Kennedy.
	2 11	Point Loma	32 43	117 15	3-4	1	3	None	Recorded on seismoscope	F. J. Dick.
	2 11	Redlands	34 04	117 12	2	1		Faint		Paul W. Moore.
	2 11	Riverside	33 58	117 21	3	2	2	None		J. D. Cox.
	2 11	San Diego	32 43	117 10	2	1	3	None		U. S. Weather Bureau.
	2 11	Valley Center	33 13	117 03	5	1		Rumbling		Ben Amigo.
	2 11	Warner Springs	33 17	116 37	4	1	15	Rumbling	Houses trembled	J. A. Ream.
30	4 25	El Centro	32 50	115 32	4	1	50		Dishes rattled	Western Union.
	4 25	Indio	33 43	116 12	4-5					Western Union.
	4 25	Niland	33 16	115 31						Western Union.
		IDAHO.								
10	2 57	Hailey	43 32	114 20	5	1	0 30	Rumbling		G. C. Hendrickson.
		NEVADA.								
11	12 00	Eureka	39 23	115 59	3	3	0 3	Rumbling		Clay Simms.
		SOUTH CAROLINA.								
24	9 42	Summerville	33 03	80 14	1	1				E. H. Gadsden.

TABLE 2.—*Instrumental seismological reports, September, 1916.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols see this REVIEW, January, 1916, p. 39.]

Date.	Character.	Phase.	Time.	Period. T.	Amplitude.		Distance.	Remarks.
					A_E	A_N		

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. J. W. Green.

Lat., 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{cases} E & 10 & 16.7 \\ N & 10 & 15.6 \end{cases}$ (V, T_0)

(No earthquake recorded during September, 1916.)

Arizona. *Tuscon. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: $\begin{cases} E & 10 & 13.9 \\ N & 10 & 19.1 \end{cases}$ (V, T_0)

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
			H. m. s.	*Sec.*	μ	μ	*Km.*	
1916. Sept. 21		eL_E	18 50 27	4				
		eL_N	18 50 34	3				
		M_N	18 51 25	5		20		
		C_E	18 54 34	4				
		C_N	18 56 41	4				
23		e_N	5 49 13	4				
		e_E	5 49 18	6				
		L_E	5 59 00					
		M_E	6 02 51	16	20			
		M_N	6 05 28	16		10		
		F	6 22 00					

TABLE 2.—*Instrumental seismological reports, September, 1916*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

California. *Berkeley. University of California.*

Lat., 37° 52′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(See Bulletin of the Seismographic Stations, University of California.)

California. *Point Loma. Raja Yoga Academy.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 2	....		....	....	*100	*100	......	Tremors recorded during 24 hours preceding 15h on dates given.
11	....		....	....	*50	*100	......	
20	....		....	....	*100	*100	......	
25	....		....	....	*200	*200	......	
30	I_d.....		2 11 00	....	*300	*300	......	Light shock lasting about 2 seconds.
30			....	....	*200	*200	......	Tremors between 2h 30m and 15h.

* Amplitude on instrument.

California. *Santa Clara. University of Santa Clara.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 03″ W. Elevation, 27.43 meters.

(See record of the Seismographic Station, University of Santa Clara.)

Colorado. *Denver. Sacred Heart College.* Earthquake Station. A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 7	....	L_N....	3 40 00	....	......	......	......	Activity at intervals. More pronounced on N-S.
	....	F_N....	5 10 00	....	......	......	......	
17	....	L_N....	19 49 00	....	......	......	......	Wavelets visible. Doubtful as to being seismic.
		F_N....	19 51 00	....	......	......	......	
18	....	L_N....	21 58 00	....	......	......	......	Too small to be analyzed, yet quite discernible.
		M_N....	21 59 00	....	......	......	......	
		F_N....	22 01 00	....	......	......	......	
18	....	P_N....	22 20 00	....	......	......	......	Clearer and stronger than preceding. Visible wavelets at intervals during day.
		L_N....	22 23 00	....	......	......	......	
		M_N....	22 28 00	....	......	......	......	
		F_N....	22 36 00	....	......	......	......	
21	....	P.....	18 45 00	....	......	......	......	Visible activity at intervals during day.
		L.....	18 46 00	8-9	6-8	6-8	......	
		F.....	18 49 00	....	......	......	......	

District of Columbia. *Washington. U. S. Weather Bureau.*

Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum, undamped. Mechanical registration).

Instrumental constants: V 110 T_0 6.4

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 3	....	eL....	8 18 30	20	......	......	......	Amplitudes very small. Not recorded on E-W.
		L.....	8 27 15	....	......	......	......	
		F.....	8 40 00	....	......	......	......	
11	I_u.....	iP.....	6 50 12	....	......	......	9,010	
		iS.....	7 00 23	....	......	......	......	
		L.....	7 14 12	....	......	......	......	
		F.....	7 30 00	....	......	......	......	

District of Columbia. *Washington. U. S. Weather Bureau*—Con.

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 15	....	eP?...	7 14 16	....	......	......	2,650?	Record very faint.
		ePR?.	7 18 33	....	......	......	......	
		eS?....	7 24 42	....	......	......	......	
		L.....	7 38 30	....	......	......	......	
		L_E....	8 00 30	20	......	......	......	
		L_N....	8 04 00	....	......	......	......	
		F.....	8 20 00	....	......	......	......	
21	I_r.....	eP....	19 00 38	....	......	......	2,850?	
		eS?....	19 05 10	....	......	......	......	
		L?....	19 07 06	....	......	......	......	
		F.....	19 25 00	....	......	......	......	
21	I_r.....	P.....	19 51 46	....	......	......	3,040	
		S.....	19 56 32	....	......	......	......	
		L.....	20 00 00	....	......	......	......	
		F.....	20 10 00	....	......	......	......	
23	II_r....	P.....	5 48 56	....	......	......	3,420	Record well defined.
		S.....	5 54 08	....	......	......	......	
		L.....	5 59 12	20	......	......	......	
		F.....	6 50 00	....	......	......	......	
24	I_r.....	P?....	19 54 36	....	......	......	2,250?	
		S.....	19 58 20	....	......	......	......	
		L?....	20 00 16	....	......	......	......	
		F.....	20 20 00	....	......	......	......	
25	I_r.....	P?....	2 27 10	....	......	......	2,080?	Very faint record.
		S.....	2 30 40	....	......	......	......	
		L?....	2 33 00	....	......	......	......	
		F.....	2 55 00	....	......	......	......	
29	I_u.....	P.....	19 03 52	....	......	......	5,510	
		S.....	19 11 02	....	......	......	......	
		L.....	19 16 32	....	......	......	......	
		L.....	19 26 00	20	......	......	......	
		F.....	19 40 00	....	......	......	......	

District of Columbia. *Washington. Georgetown University.* F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.

Instrumental constants:

	V	T_0	ϵ
E	165	5.4	0
N	143	5.2	0
Z	80	3.0	0

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 21	....	eP_E...	19 01 30	....	......	......	......	Microseisms present; P, difficult to discern.
		eP_N...	19 01 36	....	......	......	......	
		S......	19 05 33	....	......	......	......	L, doubtful.
		eL_N...	19 07 09	....	......	......	......	
		L_E?...	19 08 51	11	......	......	......	
		F.....	19 45 00	....	......	......	......	
23	....	eP_E...	5 48 44	....	......	......	......	
		eP_N...	5 48 49	....	......	......	......	
		iS_E....	5 54 10	....	......	......	......	
		S_N....	5 54 12	....	......	......	......	
		eL_E...	5 58 30	20	......	......	......	
		eL_N...	5 58 58	20	......	......	......	
		M_E....	6 00 58	....	1	......	......	
		M_N....	6 01 22	....	......	4	......	
		F.....	6 15 00	....	......	......	......	
24	....	e_N....	19 54 30	....	......	......	......	Phases not discernible. Bosch-Omori shows e at 19h 54m 53s.
		e_E....	19 54 38	....	......	......	......	
		F.....	20 18 00	....	......	......	......	
28	....	e_N....	15 57 28	....	......	......	......	Questionably of seismic origin. Microseisms.
		e_E....	15 57 31	....	......	......	......	
		F.....	16 18 00	....	......	......	......	

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Frank Neuman.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant.. T_0 18.6

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 3	....	P.....	7 23 06	....	......	......	......	
		S?.....	7 31 00	....	......	......	......	
		L.....	7 42 00	24	......	......	......	
		M.....	7 46 48	....	*2,800	......	......	
		C.....	7 53 54	....	......	......	......	
		F.....	10 48 00	....	......	......	......	

*Trace amplitude.

TABLE 2.—*Instrumental seismological reports, September, 1916*—Continued.

Hawaii. *Honolulu.—Magnetic Observatory*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 11		eP	6 53 18					
		S	7 00 42					
		L	7 08 00	18				
		M	7 19 48		*500			
		C	7 23 00					
		F	7 55 30					
14		e	18 38 12	16				
		M	18 39 06		*300			
		F	18 42 12					
15		P	7 11 00					
		S	7 18 12					
		L	7 27 12	17				
		M	7 18 12		*2,500			
		M	7 35 12		*1,500			
		C	7 50 00					
		F	8 15 00					
17		e	8 26 30					
		L	8 34 54	17				
		M	8 38 00		*100			
		F	8 39 30					
23		P	5 54 30					
		S	6 03 30					
		L	6 14 00	20				
		M	6 18 42		*500			
		C	6 27 00					
		F	6 58 00					
28		e	11 16 00					
		F	11 37 00					
29		P	19 18 30					
		L	19 34 06	24				
		M	19 40 30		*500			
		C	19 43 30					
		F	19 45 42					

* Trace amplitude.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants	V	T_0	ε
E	177	3.4	4.0
N	205	3.4	3.8

(No earthquake recorded during September, 1916.)

Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants	V	T_0
E	10	32
N	10	27

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 23		e_E	5 49 02	4				
		e_N	5 49 09	4				
		S_N	5 53 23	8				
		L_N	5 58 59	17				
		M_E	6 00 15	15	10			
		M_N	6 01 31	20		90		
		C_N	6 06 00	16				
		C_E	6 09 00					
		F	6 23 00					

Massachusetts. *Cambridge. Harvard University* Seismographic Station. J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori, 100 kg., horizontal pendulums (mechanical registration.)

Instrumental constants	V	T_0	ε:1
E	80	23	0
N	50	25	4:1

(Report for September, 1916, not received.)

Missouri. *St. Louis. St. Louis University.* Geophyiscal Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation, 12 feet of tough clay over limestone of Mississippi System, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants	V	T_0	ε:1
	80	7	5:1

(Report for September, 1916, not received, instrument out of order.)

New York. *Buffalo. Canisius College.* John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

Instrumental constants	V	T_0	ε: 1
	80	7	5:1

(Report for September, 1916, not received.)

New York. *Fordham. Fordham University.* W. C. Repetti, S. J.

Lat., 40° 51′ 47″ N.; long., 73° 53′ 08″ W. Elevation, 23.9 meters.

Instrument: Wiechert, 80 kg.

Instrumental constants	V	T_0	ε:1
E	72	6.6	1.5:1
N	72	7.1	3.8:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 21		L_N	19 02 00					
23		eP_N	5 44 28					
		eP_E	5 45 55					
		eS_N	5 50 16					
		S_E	5 50 19					
		L_E	5 53 26					
		L_N	5 54 40					
		M_N	5 57 42	19		18		
		F	6 15 00					
29		eP_E	18 58 07					
		eP_N	18 58 29					
		eS_N?	19 04 48					
		L_N	19 17 00					No decided maximum.
		F_N	19 35 00					

New York. *Ithaca. Cornell University.* Heinrich Ries.

Lat., 42° 26′ 58″ N.; long., 76° 29′ 09″ W. Elevation, 242.6 meters.

Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration).

Instrumental constants	V	T_0	ε
E	13	22	4:1
N	14	25	4:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 3		eL_E	8 13 23	30				
		F_E	8 46 00					
5		eL_E	23 27 05	20				
		F_E	23 53 00					
23		eP_N	5 49 42	5				
		eP_E	5 49 50	4				
		S_N	5 55 09	6				
		L_N	6 00 43	27				
		L_E	6 00 48	20				
		F	6 24 00					

TABLE 2.—*Instrumental seismological reports, September, 1916*—Continued.

Panama Canal Zone. *Balboa Heights.* Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters.

Instruments: Two Bosch-Omori, 100 kg.

Instrumental constants.. V 10, T_0 20

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 11		P_E	10 18 10				299	Direction NW?
		P_N	10 18 12					
		S_E	10 18 34					
		S_N	10 18 36					
		L_E	10.18 46					
		L_N	10 18 48					
		M_E	10 18 50		450			
		M_N	10 18 52			500		
		F_N	10 22 30					
		F_E	10 23 00					
23		P	5 44 35				966	Probable direction north.
		S_N	5 46 15					
		S_E	5 46 23					
		L_E	5 47 00					
		L_N	5 47 05					
		M_N	5 47 17			800		
		M_E	5 49 35		150			
		F_E	6 03 00					
		F_N	6 06 20					

Porto Rico. *Vieques.* *Magnetic Observatory.* U. S. Coast and Geodetic Survey. H. M. Pease.

Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants.. E: V 10, T_0 21.4; N: V 10, T_0 21.1

(Report for September, 1916, not received.)

Vermont. *Northfield.* *U. S. Weather Bureau.* Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants.. E: V 10, T_0 15; N: V 10, T_0 16

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1		eL	3 03 00					Record barely perceptible.
		L	3 10 00					
		F	3 15 00					
3		e	8 29 30					Record very feeble; does not show on E-W.
		F	8 35 00					
11	I_u	P	6 49 51				9,010?	
		S?	7 00 02					
		L?	7 14 12					
		F	7 25 00					
15		e	7 14 47					Record very feeble on N-S and not perceptible on E-W.
		F	7 30 00					
21		eP?	19 00 34					
		e?	19 07 22					
		F	19 20 00					
23	I_r	P	5 49 49				4,150	
		S	5 55 45					
		L	5 59 15	8				
		L	6 01 00	20				
		F	6 25 00					
24		e	19 55 10					
		S?	19 59 20					
		L?	20 01 32					
		F	20 15 00					
29	I_u	P	19 04 18				6,125	
		S	19 12 01					
		L?	19 16 06					
		F	19 30 00					

Canada. *Ottawa.* *Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants.. V 120, T_0 26

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Sept. 1		eL_N?	2 54 24	8				
		L_N	2 55 24	14				
		L_N	3 03 00	20				
		L_N	3 10 00	20				
		F	3 17 00					
3		*O*	*7 11 00*				14,000	*O* and distance approximate.
		PR2?	7 34 21					
		S	7 43 51					
		eL_N?	8 10 00	40				
		L_N	8 12 00	28				
		L_N	8 15 00	24				
		L	8 19 00	20				
		L	8 28 00	16				
		L	8 42 00	16				
		$LR1_N$?	9 03 00	16				
		$LR1_N$	9 20 00	20				
		F	9 30 00					
5		e_E	22 45 18	14				Very distant.
		e_E	22 47 00	13				
		L	23 17 18	22				
		L	23 22 00	19				
		L	23 24 00	18				
		F	23 40 00					
11		e	6 49 54				14000?	
		i	6 53 49					
		iS?	6 59 48					
		eL_N	7 40 00	40				
		L_N	7 42 00	24				
		L_N	7 48 00	20				
		L_E	7 51 00	20				
		L	{7 53 00 8 12 00}	20				
		F	8 30 00					
15		*O*	*7 02 12*				9,120	
		P_N	7 14 31					
		PR1	7 18 12					
		S	7 24 48					
		eL	7 42 00	36				
		L	7 50 00	30–24				
		L	7 55 00	24				
		L	8 00 00	20–18				
		L	8 03 00	18				
		F	8 20 00					
21		e	19 06 24					
		i_E	19 06 28					
		i_N	19 06 32					
		M_N	19 07 36	10				
		L	19 10 00	7–10				F masked by microseisms.
23		*O*	*5 42 30*				4,030	Velocity of L waves is 218 km. per minute.
		P	5 49 50					
		PR2	5 51 17					
		S_N	5 55 39					
		S_E	5 55 43					
		eL_N	6 01 00	40				
		L	6 03 00	22–20				
		L_E	6 08 00	17				
		L_N	6 10 00	13				
		L	6 20 00	13–14				
		F	6 45 00					
29		*O*	*18 54 45*				6,250	
		P	19 04 28					
		S	19 12 18					
		L	19 21 06	20				
		L	19 31 00	20				
		L	19 34 00	18				
		F	19 45 00					

O—time at origin.

TABLE 2.—*Instrumental seismological reports, September, 1916*—Continued.

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation, 1 mm. swing of boom=0.50″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 3		e	8 09 36					During the principal portion a slow gradual increase of movement. Resembles the Victoria die a good deal.
		e	8 13 18					
		L	8 16 42					
		eL	8 21 00					
		M	8 28 12		*1,500			
		L	9 23 30					
		F	9 43 18					
3		L	10 52 12		*100			
		F	10 59 00					
5		L?	23 13 54					May be an earthquake about 21h 50m to correspond to Victoria, but lost in air currents.
		L	23 18 48					
		eL	23 22 30					
		M	23 30 48		*800			
		e	23 39 12					
6		F	0 03 00					
6		L?	9 21 00		*50			Very gradual thickening.
		F	9 35 24					
11		L	6 59 12					
		L	7 43 06					
		L	8 20 24		*200			
		F	8 27 54					
15		L? or S	7 25 42					
		e	7 36 00					
		L	7 48 18					
		L	7 50 30					
		e	7 59 24					
		M	8 00 48		*1,000			
		F	8 48 48					
21		e	19 05 18		*50			Time very doubtful. No cut-off.
23		P?	5 48 42					
		S	5 55 48					
		eL	5 58 36					
		L	6 01 00					
		iL	6 03 48					
		M	6 05 06		*1,800			
		F	7 01 30					
24		L	18 00 00		*50			
		F	18 05 00					
28		L	12 03 42		*200			
		F	12 11 30					
29		e?	18 57 06					
		L	19 21 24		*100			
		F	19 50 00					May be air currents.

*Trace amplitude.

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instruments: Wiechert, vertical. Milne horizontal pendulum, North; in the meridian.

Instrumental constant.. T_0 18. Pillar deviation: 1 mm. swing of boom=0.54″.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Sept. 3		P	7 37 46				3,220	
		S	7 42 44					
		L?	7 50 40					
		M	8 04 03		*1500			
		F	8 43 43					
3		P	9 41 53					May be part of long-distance quake above. S?, L?.
		M	9 43 50		*100			
		F	9 49 44					
3		P	10 23 52					May be part of long-distance quake above.
		L?	10 26 50					
		M	10 31 48		*200			
		F	10 35 46					
5		P?	21 50 03					S and L not determined.
		M	21 55 36		*100			
		F	22 00 59					
5		P	22 38 39				3,330	
		S	22 43 37					
		L	22 56 31					
		M	23 02 27		*500			
		F	23 37 10					
6		P	8 50 32					
		L	8 55 30					
		M	8 59 58		*100			
		F	9 16 20					
11		P	6 58 21				6,360?	
		S?	7 06 16					
		L	7 13 43					
		M	7 33 33		*300			
		F	8 40 30					
15		P?	7 10 12				7,530?	
		S?	7 19 08					
		L?	7 31 02					
		M	7 45 55		*200			
		F	8 32 31					
19		P	11 05 45				550	
		L	11 06 45					
		M	11 07 45		*200			
		F	11 09 15					
21		P	18 56 15				820	
		L	18 57 44					
		M	18 59 13		*300			
		F	19 01 12					
23		P	5 56 42				3,670?	May be off the west coast of Mexico.
		S?	6 02 10					
		L	6 08 16					
		M	6 19 31		*1000			
		F	6 53 44					
24		P?	17 42 00					
		M	17 43 10		*200			
		F	17 44 00					
24		P	19 37 40				550?	
		L	19 38 40					
		M	19 39 40		*300			
		F	19 42 10					
25		P	2 10 35					
		M	2 11 34		*200			
		F	2 13 03					
26		P	15 52 35					
		M	15 53 05		*100			
		F	15 54 35					
26		M?	22 17 35					Doubtful as to being seismic.
28		P or L	11 43 43					
		M	11 47 11		*200			
		F	11 53 08					
29		P	19 29 02				1,810	
		S?	19 32 08					
		L	19 34 02					
		M	19 37 02		*500			
		F	19 43 32					

* Trace amplitude.

TABLE 3.—*Late seismological reports.* (*Instrumental.*)

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

New York. *Ithaca. Cornell University.* Heinrich Ries.

Lat., 42° 26′ 58″ N.; long., 76° 29′ 09″ W. Elevation, 242.6 meters.

Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration).

		V	T_0	ϵ
Instrumental constants..	E	13	22	4:1
	N	14	25	4:1

Date.	Character.	Phase.	Time.	Period. T.	A_E	A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Aug. 3	....	i_N	1 51 57	3				
		e_E	1 52 14	6				
		—$_N$	2 01 34	6–30				
		—$_E$	2 03 38	12				
		L_E	2 35 34	20				
		F_N	2 43 00					
		F_E	2 52 00					
3	....	e_N	9 18 30	4–12				
		F_N	9 26 00					
3	....	e_N	14 36 23	5				
		e_E	14 36 39	4				
		—	14 39 07	12				
		F_N	14 56 00					
		F_E	15 12 00					
25	....	P_N	9 55 08	3				
		S	10 03 46	4–6				
		L_E	10 15 32	36				
		L_N	10 16 04	33				
		F_E	10 29 00					
		F_N	10 33 00					
28	....	e_N	6 58 16	4				
		—$_N$	7 00 31	4				
		e_E	7 04 32	6				
		i	7 04 37	6				
		eL_E	7 26 36	22				
		eL_N	7 35 18	25				
		—	7 48 12	15				
		F_N	8 45 00					
		F_E	8 48 00					

SEISMOLOGICAL DISPATCHES.[1]

San Juan del Sud, Nicaragua, Sept. 23, 1916.

A heavy earthquake shock was felt here early to-day. No reports of damage have been received. (*Assoc. Press.*)

Los Angeles, Cal., Sept. 29, 1916.

El Centro and other towns in the Imperial valley reported that several earthquake shocks had been felt to-day and to-night but that no damage had been caused. A tremor was felt also at San Diego, registering on the seismoscope at the Point Loma Observatory. It was estimated that the center was very distant. (*Assoc. Press.*)

[1] Reported by the organization indicated and collected by the seismographic station at Georgetown University, Washington, D. C.

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological and seismological work and studies.

Blanco Juste, Rafael.
Elementos de física y nociones de meteorología. 5 ed. Madrid. 1915. 325, [2] p. 22 cm.

Bollo, Luis Cincinato.
Climatología Platense. Montevideo. 1916. 32 p. 19½ cm. (De la 6ª edición de la Geografía física de L. C. Bollo.)

Committee for the investigation of atmospheric pollution. *London, 1912.*
First report, presenting the results obtained for the year April, 1914, to March, 1915. London. [1916.] xl p. 28 cm. (Reprinted from the Lancet, Feb. 26, 1916.)

Gray, Richard W.
Summer temperatures at Miami. (*In* the Tropic magazine, Miami, Fla. Sept., 1916. v. 4, p. 158-160. 27 cm.)

Hildebrandsson, H[ugo] Hildebrand].
Sur le prétendu changement du climat Européen en temps historique. Upsala. 1915. 31 p. 3 pl. 29 cm. (Nova acta Reg. soc. sci. Upsaliensis, ser. iv, v. 4, n. 5.) [See this REVIEW, June, 1916, 44:344.]

Hubbard, Arthur John, & Hubbard, George.
Neolithic dew-ponds and cattle-ways. 3d ed. London, *etc.* 1916. xxiv, 115 p. (incl. plates). 25½ cm.

Huntington, Ellsworth.
Prediction of climatic variations. (*In* the American museum journal, New York. Feb., 1916. v. 16, p. 96-103. 25 cm.)

Mascart, Jean.
Esquisse sur le raccordement climatologique des Départements du Rhône et de la Loire. [Lyon. 1916.] 11 p. 24 cm.

Mercanton, P.-L.
Les variations périodiques des glaciers des Alpes suisses. 35ᵐᵉ et 36ᵐᵉ rapports. 1914 et 1915. Berne. 1916. p. 237-256. plate. 26½ cm. (Extrait de l'Annuaire du S. A. C., 50ᵐᵉ année.)

Radcliffe observatory, Oxford.
Results of meteorological observations in the five years 1911-1915, also of underground temperatures, 1898-1910. v. 51. Oxford, *etc.* 1916. xv, 215 p. 25½ cm.

Ramsay, William.
The gases of the atmosphere. The history of their discovery. 4th ed. London. 1915. xiii, 306 p. plates. 20½ cm.

[Reed, William Gardner.]
Elementary meteorology. Geography 1B. Berkeley. 1914. 37 p. 21 cm. (University of California, syllabus series, no. 46.)

Stewart, Charles.
Meteorological data of Spokane, Washington, for 34 years, 1882-1915. (*In* 24th annual report of the Health & sanitation dept., city of Spokane, for the year ending Dec. 31, 1915. p. 34-38. 24 cm.)

Strahan, Aubrey, & *others*.
The investigation of rivers. Final report. London. 1916. 2 p. l. 93 p. 9 pl. 24½ cm. (Royal geographical society. Special publication.) [Results of "an examination of certain rivers in England and Wales." Includes statistics of discharge and rainfall.]

Tippenhauer, L. G.
Die elektromagnetische Theorie des Wetters. 4. Teil: Die ersten Prinzipien einer astronomischen Berechnung des Wetters. Port-au-Prince. 1916. v. p. plates. tables. 31 cm.

Venice. Ufficio idrografico.
Norme ed istruzioni per il Servizio meteorologico. (Edizione provvisoria.) Venezia. 1916. 61 p. plates. 26 cm. (Pubblicazione n. 53, parte 1ª (testo).]

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Cairo scientific journal. Alexandria. v. 8. December, 1914.
Birkeland, Kr. On a possible method of photographically registering the intensity of the ultraviolet light from the sun and stars. p. 287-294.

Geographical review. New York. v. 2. October, 1916.
Brooks, Charles F. World-wide changes of temperature. p. 249-255.

Indian meteorological department. Memoirs. Simla. v. 21. pt. 14.
Jacob, S. M. Correlation of rainfall and the succeeding crops, with special reference to the Punjab. p. 131-146.

Royal meteorological society. Quarterly journal. London. v. 42. July, 1916.
Shaw, Napier. The meteorology of the globe in 1911. p. 137-152.
Newnham, E. V. The persistence of wet and dry weather. p. 153-162. [See this REVIEW, July 1916, p. 393.]
Turner, H. H. Discontinuities in meteorological phenomena. Second note. p. 163-173.
Marriott, William. Luke Howard's meteorological journals. p. 175-180.
Hall, Maxwell. West Indian cyclones and the local wind. p. 183-189.
Mr. C. F. Casella. p. 191-192. [Obituary.]

Scientific American. New York. v. 115. 1916.
Frederick, K. P. Can we put the sun to work? p. 329; 336. (Oct. 7.)
A device which automatically regulates the moisture in the air. p. 355. (Oct. 14.)

Scientific American supplement. New York. v. 82. October 28, 1916.
McAdie, Alexander. Thermometer scales. p. 282.

Archives des sciences physiques et naturelles. Genève. t. 42. 1916.
Gruner, P[aul]. Nouvelles remarques concernant les lueurs crépusculaires du ciel. p. 32-46. (15 juillet.)
Schwoerer, E. Nouvelles recherches sur la détermination de la constante solaire. p. 119-122. (15 août.)
Horwitz, L. Sur la variabilité absolue de la température annuelle en Suisse. p. 153-154. (15 août.)

Nature. Paris. 44 année. 1916.
Paresce, René. Une nouvelle méthode de prévision du temps. p. 197-199. (23 sept.) [Describes F. Vercelli's method of analyzing atmospheric waves.]
Breton, A. Nouvelle hygromètre à condensation. p. 237-238. (7 oct.) [describes hygrometer devised by Ch. Margot.]

Weltall. Berlin. 14. Jahrg. 1. und 2. Augustheft. 1914.
L. Die Gestalt fallender Tropfen. p. 342.

Hemel en dampkring. Den Haag. 14 jaarg. 1916.
Cannegieter, H. G. Temperatuur, luchtdruk en wind in de hoogere dampkringslagen. p. 54-56; 72-78. (Aug. & Sept.)

Pontificia accademia romana dei Nuovi Lincei. Atti. Roma. anno 69. 1915-1916.
Galli, Ignazio. Fulmini globulari nell'anno 1915. Nota 14. p. 59-72.
Galli, Ignazio. La pioggia straordinaria degli anni 1914 e 1915. p. 79-86.

Reale Accademia dei Lincei. Atti. Roma. v. 25. 2 sem. no. 1. 1916.
Oddone, Emilio. Per la teoria della dispersione sismica. p. 35-41.

Secretaria da agricultura, Commercio e obras publicas. Boletim. Sao Paulo. sér. 17. Abril-Maio 1916.
Mattos, José Rangel Belfort de. Resumo de instrucções meteorologicas. p. 368-384.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

MAITLAND C. BENNETT, Acting Chief of Division.

[Dated: Weather Bureau, Washington, Nov. 1, 1916.]

PRESSURE.

The distribution of the atmospheric pressure over the United States and Canada and the prevailing direction of the winds are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

The mean barometric pressure for the month was below the normal from Iowa and Minnesota eastward; also over most of North Dakota, the northeastern portion of Montana, and in a few local areas to the westward of the Rocky Mountains. The monthly means were likewise below the normal in most sections of the Canadian Provinces. Elsewhere the pressure was, as a rule, above the normal. The minus departures were generally small, but were greatest in the region of the Great Lakes and in the adjacent Canadian districts. The plus departures were also small, being mostly less than 0.04 inch.

During the first few days of the month pressure was relatively high from the Rocky Mountains eastward, but about the 3d a rather pronounced low area appeared in the Northwest, and during the following few days it moved eastward, but with decreasing intensity. Thereafter till near the middle of the month no pronounced abnormal pressures obtained, but there was a tendency to relatively high readings in most districts. From the 14th to the 20th moderately high pressure was the rule over eastern districts, but during the first few days of the last decade of the month rather low readings were recorded along the northern border to the eastward of the Rocky Mountains, especially in the region of the Great Lakes, and like conditions obtained in those districts on the 27th and 28th. The month closed with an extensive area of high pressure overlying the districts from the Mississippi Valley eastward.

The distribution of the highs and lows was such as to favor prevailing southerly winds in most sections from the Great Plains States eastward, except that in the Southeastern States the direction of greatest frequency was northeast. In the Pacific coast region there were frequent northerly winds during the month, while in most of the Rocky Mountain and Plateau districts variable winds prevailed.

TEMPERATURE.

During the first few days of the month high temperatures obtained in the northern Rocky Mountain districts, 102° being recorded at Miles City, Mont., on the 2d, but at the same time cool weather prevailed in portions of New York and New England where local frosts occurred on the mornings of the 3d and 4th, and on the 4th a sharp fall in temperature occurred in the mountain districts of the West. The temperature for the first decade of the month averaged considerably above the normal in nearly all districts to the eastward of the Rocky Mountains, but in the western Plateau States it was cooler than usual for the season of the year.

The second decade brought much lower temperatures to interior districts, the week ending September 19 being exceptionally cool for the season in the upper Mississippi and central Missouri valleys, where the average temperature for the week ranged from 10° to 12°, or more, below the normal.

No marked temperature changes occurred during the last decade until near the end of the month, when an extensive high-pressure area overspread the country from the Rocky Mountains eastward, accompanied by a sharp fall in temperature in those districts. On the morning of the 28th freezing temperatures occurred in northern Minnesota, the Dakotas, western Nebraskas Wyoming, and Montana, and at the close of the month frosts had occurred in the Ohio and Mississippi valleys as far south as western Tennessee.

The mean temperature for the month was near the normal in nearly all sections of the country, the departures being generally less than 3°, except locally in the northern Great Plains and adjacent Rocky Mountain districts, where the minus values were slightly more than 3°, and in the San Francisco Bay section, where similar plus departures were recorded. No marked extremes of temperature occurred over wide areas during the month, although locally there were rather high readings for the season, the maximum being 110° at Yuma, Ariz., on the 1st. Freezing temperatures occurred at a few scattered points in New England, northern New York, Michigan, and Wisconsin, and generally in Nebraska, the Dakotas, and Montana. The lowest reading reported for the month was 21° at Yellowstone Park, Wyo., on the 21st.

PRECIPITATION.

During the first decade of the month showers were rather frequent in the central and northern districts to the eastward of the Rocky Mountains, and some heavy local falls occurred in the Ohio Valley on the 1st and in the region of the Great Lakes and the upper Mississippi Valley from the 3d to the 8th. At the beginning of the second decade generous rains fell in most districts between the Mississippi River and the Rocky Mountains, which largely relieved the severe drought that had prevailed for a long time in some sections of that area. During most of this decade, however, rainfall was generally light and local, although quite extensive and substantial rains occurred in the Gulf and Atlantic coast districts from the 12th to the 15th. During the first half of the last decade only light local showers occurred, but on the 26th general rains set in from Idaho to the Lake region, and during the closing days of the month the rain area overspread nearly all districts to the eastward of the Rocky Mountains.

The total rainfall for the month as a rule was less than the normal to the eastward of the Mississippi River. It was heavier than usual in portions of California, Iowa, Wisconsin, upper Michigan, and the interior of the northeastern States. The monthly totals were less than one-half inch in large areas to the westward of the Rocky Mountains; also in eastern Colorado, and the western portion of Nebraska and South Dakota. No heavy rainfall

of special note occurred during the month in any section of the country. The heaviest recorded monthly amounts fell in the eastern portion of North Carolina and the Florida Peninsula, the central portions of Pennsylvania and New York, and in the upper Mississippi Valley and upper Lake region, where limited areas received as much as 6 inches.

RELATIVE HUMIDITY.

The mean relative humidity for the month was below the normal in most districts to the eastward of the Rocky Mountains, the only noteworthy exceptions being the northern border States from the region of the Great Lakes westward and locally in the Great Plains region, where the month as a whole was damper than usual. From the Rocky Mountains westward the atmosphere was also relatively damp in the northern and the southern districts, but in the central States, including Colorado, Utah, Wyoming, southern Idaho, and most of Nevada, as well as in the central Pacific coast district, the month was drier than the average.

GENERAL REMARKS.

The weather during September, 1916, was generally favorable for the prosecution of fall work, and rapid progress was made in seasonal farming operations. Harvesting and the threshing of grain advanced rapidly with little interruption, although rain caused some delay to this work in the upper Mississippi Valley and portions of the Rocky Mountain and North Pacific States. The weather was favorable for fall plowing and seeding in most districts, but there was considerable complaint of the soil being too dry for proper preparation and for germination of seed in some localities. The month was exceptionally favorable for the gathering of cotton, hay, and fodder, but at the close of the month fall pastures, late feed crops, and late truck and gardens were, as a rule, much in need of rain.

Average accumulated departures for September, 1916.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	In.	In.	In.	0-10		Perct.	
New England	60.8	+0.5	− 5.8	2.48	−0.80	−2.00	4.6	−0.6	79	−2
Middle Atlantic	65.9	−0.7	+ 5.8	2.48	−0.80	−3.00	4.0	−0.6	73	−4
South Atlantic	72.2	−0.8	+ 8.4	2.92	−1.80	−9.50	3.9	−0.8	77	−3
Florida Peninsula	80.5	−0.5	− 2.6	4.52	−2.80	−9.90	5.2	−0.2	78	−3
East Gulf	74.6	0.0	+ 6.6	2.83	−0.90	−0.90	3.4	−1.2	74	−2
West Gulf	76.7	+0.6	+11.4	2.44	−1.00	−4.50	3.4	−0.8	69	−5
Ohio Valley and Tennessee	66.6	−1.4	+ 0.8	2.72	0.00	−0.30	3.7	−0.7	70	−2
Lower Lakes	62.9	−0.2	− 0.4	2.56	−0.20	−1.20	5.1	+0.3	68	−5
Upper Lakes	58.2	−1.2	+ 0.7	3.82	+0.70	+1.90	5.9	+0.7	76	−1
North Dakota	55.4	−1.6	−15.6	1.30	−0.10	+0.90	4.4	0.0	72	+6
Upper Mississippi Valley	62.8	−1.3	+ 2.8	3.71	+0.20	−1.00	4.7	+0.4	73	+1
Missouri Valley	64.8	−0.5	+ 3.3	2.48	−0.20	−5.50	3.5	−0.5	67	+1
Northern slope	56.2	−1.1	−10.8	0.95	−0.20	−0.10	3.6	−0.4	57	+2
Middle slope	68.6	−0.1	+ 4.0	1.61	−0.60	−4.00	3.2	−0.2	59	+1
Southern slope	72.1	−0.7	+15.1	1.28	−1.30	−4.40	3.1	−0.7	61	−2
Southern Plateau	70.0	−0.6	− 1.1	0.92	−0.10	+1.00	2.4	−0.1	47	+8
Middle Plateau	62.6	0.0	− 2.5	0.42	−0.20	+0.20	1.8	−1.1	37	−1
Northern Plateau	60.8	−0.4	−14.9	0.25	−0.50	+1.70	3.4	−0.2	45	−7
North Pacific	59.9	+1.1	− 6.0	0.66	−1.80	−6.10	4.9	−0.4	76	+4
Middle Pacific	63.9	+0.5	+ 0.6	0.89	+0.10	+0.50	3.1	−0.3	60	−7
South Pacific	66.5	−0.8	− 1.4	0.84	+0.60	+5.10	2.9	+0.3	71	+5

WEATHER CONDITIONS ON THE NORTH ATLANTIC OCEAN DURING SEPTEMBER, 1915.

The data presented are for September, 1915, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month. Chart IX (XLIV–121) shows for September, 1915, the averages of pressure, temperature, and the prevailing direction of the wind at 7 a. m., 75th Meridian time (Greenwich mean noon), together with the locations and courses of the more severe storms of the month.

PRESSURE.

The distribution of the average pressure for the month, as shown in Chart IX, presents few unusual aspects. The Azores HIGH was practically normal in location and intensity, and the same can be said of the Icelandic LOW, which was but slightly south of its normal position. A slight depression of 30 inches surrounded the Bermudas, due to unusually low pressure during the first decade of the month, and the continental HIGH with a crest of 30.10 inches was central near Elkins, W. Va., extending as far east as the 72d meridian. While the average pressure gradients for the month were not steep, the range of pressure from day to day was very marked in some localities. In the 5-degree square that includes St. Johns, Newfoundland, the barometer readings ranged from 30.28 inches on September 2 to 28.85 inches on the 27th, the monthly mean being 29.86 inches.

As a rule, north of the 35th parallel and west of the 55th meridian, the pressure was above the average during the first decade of the month, also from the 13th to the 17th, and from the 23d to the 25th, while a marked depression existed from the 27th to the 30th. During the remaining periods of the month the pressure was not far from normal. In the waters adjacent to the European coast, high pressure prevailed from the 5th to the 11th, and from the 15th to the 17th, while low barometric readings were reported from the 25th to the 29th. Unusually low pressure existed in the vicinity of the Bermudas between the 2d and the 9th, the lowest barometric reading, 29.17 inches, occurring on the 3d. This unusual reversal of normal conditions affected the monthly mean to a slight extent, and was responsible for the LOW shown on Chart IX, and mentioned previously. The West Indian hurricane that prevailed from September 22 to October 2 caused low pressures for a number of days in the Caribbean Sea and Gulf of Mexico, but did not affect the monthly means materially.

GALES.

On Chart III (XLIII–106) Tracks of Centers of Low Areas, for September, 1915, a LOW (I on Chart IX) is shown that first appeared on September 2 about 4° east of Bermuda. The path followed by this disturbance was unusually erratic. After starting toward the northwest, it curved toward the south and southeast, then, recurving through the west and northwest, it started in a northeasterly direction and on the 9th was central near latitude 35°, longitude 65°, where a number of vessels reported southeasterly to southwesterly gales of from 40 to 55 miles an hour.

The disturbance continued in its northeasterly course with an increased rate of movement, and on the 10th the center was near latitude 40°, longitude 61°. Heavy winds still prevailed south of the center, decreasing as the American coast was approached, while fog was encoun-

tered a short distance east of New York. On the 11th the center was about 150 miles south of St. Johns, Newfoundland; gales of from 40 to 55 miles an hour were reported between the 35th and 38th parallels, although the storm area was not large, as between the 65th meridian and the American coast the winds were light and variable. On the 12th the disturbance was central near latitude 50°, longitude 44°, where the area had increased in extent and the winds diminished in force since the previous day, although the barometer had fallen slightly. Still traveling toward the northeast, the LOW was near latitude 55°, longitude 36°, on the 13th; the barometer reading at the center had fallen to 29.15 inches, and the storm area was larger in extent, as gales were encountered along the path of the northern steamer routes west of the 30th meridian. This LOW remained nearly stationary from the 14th to the 24th, and heavy winds prevailed near its center during the greater part of that period.

On September 22 a slight depression existed near latitude 15°, longitude 64°, that afterward developed into one of the severest West Indian hurricanes ever experienced. This storm was fully discussed by Mr. E. H. Bowie, forecaster, in a special bulletin, and also by Mr. Isaac M. Cline, in an article that appeared in the MONTHLY WEATHER REVIEW for September, 1915.

No unusually heavy winds were reported from the Caribbean Sea and Gulf of Mexico between the 22d and 27th, but on the 28th one vessel near latitude 27°, longitude 87°, recorded an easterly gale of 40 miles an hour. On the morning of the 29th, some hours before the storm reached its height in New Orleans, two vessels about 150 miles south of Mobile reported southeasterly gales of 55 miles an hour, with a barometer reading of 29.45 inches. On the morning of the following day the barometer had risen to 29.70 in this vicinity and the winds moderated in force; the center of the storm was then in eastern Mississippi and moving rapidly toward the northeast.

TEMPERATURE.

In mid-ocean north of the 50th parallel, the average mean monthly temperature was considerably above the normal, the positive departures ranging from 3° to 4°; the same conditions held true in the waters adjacent to the European coast, while in the vicinity of the Irish Channel the departure was +7°. South of the 50th parallel, between the 30th and 60th meridians, the temperatures were not far from the normal, the departures ranging from +2° to −2°, while in the waters along the American coast they were slightly positive.

The temperature departures at a number of Canadian and United States Weather Bureau stations on the Atlantic and Gulf coasts were as follows:

	°F.		°F.
St. Johns, Newfoundland..	−1.2	Norfolk....................	+2.5
Sydney, C. B. I............	+1.0	Hatteras..................	+2.4
Halifax, N. S..............	+1.8	Charleston................	+3.0
Eastport....................	+1.8	Key West.................	−0.1
Portland....................	+1.8	Tampa.....................	+3.4
Boston......................	+4.1	Pensacola.................	+1.7
Nantucket..................	+2.2	New Orleans..............	+3.2
Block Island...............	+1.3	Galveston.................	+1.8
New York...................	+2.5	Corpus Christi............	+2.8
Washington................	+2.9		

The lowest temperature reading reported during the month was 46°, and occurred in the 5° square between the 50th and 55th parallels and the 55th and 60th meridians, on the 19th, 26th, 27th, 28th, and 29th of the month; the highest temperature for the same square was 57°, and occurred on the 3d. The highest temperature recorded in any 5° square was 83°, occurring in the Caribbean Sea and Gulf of Mexico on a number of days during the month, while the lowest for the same area was 79°.

FOG.

There was somewhat less fog than usual off the Banks of Newfoundland and along the northern steamer routes, while in the vicinity of the American coast the amount was not far from the normal.

Maximum wind velocities, September, 1916.

[Velocities below 50 mis./hour (22.4 m./sec.) are not included here.]

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mis./hr.				*Mis./hr.*	
Buffalo, N. Y.....	8	50	sw.	New York, N. Y..	8	60	nw.
Detroit, Mich.....	7	68	nw.	Point Reyes Light, Cal.......	3	57	nw.
Erie, Pa...........	7	54	sw.	Do............	4	58	nw.
Little Rock, Ark..	21	50	nw.	Do............	8	64	nw.
Modena, Utah....	17	52	sw.	Do............	24	54	nw.
Mount Tamalpais, Cal............	4	68	nw.	Do............	25	55	nw.
Do............	5	67	nw.	St. Louis, Mo.....	27	56	s.
Do............	7	63	nw.	Sandy Hook, N. J.	8	56	nw.
Do............	8	72	nw.				
Do............	25	62	nw.				

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, September, 1916.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	73.8	−1.4	Thomasville	100	3	Hamilton	35	30	2.18	−1.15	Bay Minette	9.11	Cochrane	0.00
Arizona	72.0	−0.9	Aztec	114	2	Greer	20	11	1.74	+0.62	Natural Bridge	6.46	2 stations	0.00
Arkansas	72.5	−0.9	Lewisville	102	4	Kemp Wallace	30	30	3.40	−0.29	Searcy	7.51	Texarkana	0.39
California	66.4	−2.1	Greenland Ranch	116	1	Bridgeport	17	11	0.56	+0.07	Point Reyes	2.36	8 stations	0.00
Colorado	56.1	−1.2	2 stations	97	6†	Spicer	0	26	0.92	−0.55	Marble	2.87	2 stations	0.00
Florida	78.5	−1.0	4 stations	97	2†	2 stations	46	30	4.95	−2.03	Tarpon Springs	9.99	Macclenny	1.50
Georgia	73.6	−1.5	4 stations	98	2†	Dablonega	35	30	2.20	−1.25	Dublin	6.76	Lumber City	0.20
Hawaii [August]	72.8	....	Kaanapali Maui	92	6†	Waimea, Hawaii	50	6	6.36	....	Waiakamoi Maui	27.53	4 stations	0.00
Idaho	56.0	+0.4	Glenns Ferry	105	1	2 stations	13	28†	0.58	−0.48	Castle Creek	3.72	9 stations	0.00
Illinois	65.1	−1.6	Mascoutah	98	6	Montrose	26	16	2.92	−0.49	Freeport	9.05	Griggsville	1.42
Indiana	65.1	−2.0	Collegeville	98	6	Mauzy	27	30	2.96	0.00	Crown Point	6.98	Princeton	0.97
Iowa	62.5	−1.1	Clarinda	98	4†	2 stations	21	29	3.89	+0.36	Clarinda	9.71	Monroe	1.45
Kansas	67.8	−1.3	Chapman	105	5	Blakeman	22	29	2.35	−0.49	Agricultural College, Manhattan.	8.12	Tribune	0.12
Kentucky	67.2	−3.4	Earlington	98	7†	4 stations	32	16†	3.48	+0.78	Russellville	7.80	Scott	1.62
Louisiana	76.5	−1.1	Angola	105	4	3 stations	37	30	2.79	−1.11	Clinton	6.78	Logansport	0.27
Maryland-Delaware	65.3	−2.3	Western Port, Md	98	27	Oakland, Md	26	19	3.43	+0.31	Deer Park, Md	5.70	Baltimore, Md	1.82
Michigan	58.9	−1.2	Morenci	96	7	West Branch (near).	22	30	3.65	+0.69	Sidnaw	10.84	Mackinaw	1.16
Minnesota	56.7	−1.4	Albert Lea	96	5	Roseau	20	28	3.01	−0.10	Winton	8.32	Tyler	0.73
Mississippi	74.1	−1.8	5 stations	99	2†	4 stations	34	30	1.92	−1.87	Pascagoula	10.91	University	T.
Missouri	67.7	−1.5	Lebanon	101	5	Bethany	27	29	2.95	−0.86	Gano	5.69	Jefferson City	1.14
Montana	54.1	−1.0	Miles City	102	2	Bowen	9	14†	1.62	+0.19	Belton	5.26	Big Timber	0.25
Nebraska	62.8	−0.8	4 stations	100	4†	Gordon	18	15	1.31	−0.82	Falls City	5.98	2 stations	0.00
Nevada	61.6	−0.0	Logan	106	1	2 stations	16	11	0.32	−0.04	Austin	1.28	5 stations	0.00
New England	60.3	+0.5	Bridgeport, Conn	93	8	3 stations	28	4†	3.53	−0.07	Vernon, Vt	6.84	Block Island, R. I.	0.82
New Jersey	65.2	−0.6	Elizabeth	98	8	Charlotteburg	31	20	2.84	−1.11	Cape May City	5.29	Sandy Hook	1.29
New Mexico	63.1	−0.8	Gage	99	6	Rociada	19	29	0.97	−0.70	Hobbs	3.91	Pleasant View	0.00
New York	61.0	+0.6	York (3)	93	7†	Bolivar	25	19	3.79	+0.54	New Berlin	7.67	Rochester	1.01
North Carolina	68.3	−2.1	Pinehurst	99	7	Highlands	30	30	2.67	−1.20	Lenoir	6.30	Chapel Hill	0.80
North Dakota	55.0	−1.4	Bowman	99	3	Minot	15	15	1.58	−0.04	Milnor	5.26	Manning	0.03
Ohio	63.7	−2.3	Catawba Island	101	7	2 stations	27	19†	2.56	−0.19	Dayton (2)	7.27	Roxabell	0.68
Oklahoma	72.8	−1.2	Hammon	104	11	3 stations	29	29	2.43	−0.60	Hooker	6.50	Kenton	0.21
Oregon	59.6	+1.2	2 stations	97	14†	Crescent	13	12	0.71	−0.85	Government camp	3.41	5 stations	0.00
Pennsylvania	62.5	−1.4	Hamburg	98	7	West Bingham	23	19	3.77	+0.47	Gordon	8.18	Beaver Falls	0.91
Porto Rico	78.8	−0.1	Canovanas	98	11†	2 stations	60	13†	8.63	+0.51	Rio Blanco	20.17	Potala (Hacienda)	2.82
South Carolina	72.2	−2.0	2 stations	99	7	Mountain Rest	35	30	2.56	−1.38	Effingham	6.97	Georgetown	0.50
South Dakota	59.4	−1.4	Goldfield	100	3†	2 stations	18	15†	0.99	−0.55	Aberdeen	4.15	3 stations	0.00
Tennessee	68.6	−2.3	Arlington	100	6	Tazewell	31	30	2.31	−0.84	Walling	5.08	Lynnville	0.80
Texas	76.8	−0.4	Jewett	107	9	Lubbock	33	29	1.86	−1.07	Raymondville	7.79	Kopperl	T.
Utah	59.9	−0.2	St. George	102	1	Scofield	17	28	0.59	−0.56	Snake Creek	3.14	5 stations	0.00
Virginia	66.2	−2.1	Danville	100	8	Burkes Garden	26	20	2.79	−0.47	Gallaville	5.29	Danville	1.00
Washington	58.4	+0.9	2 stations	102	1†	4 stations	23	10†	0.93	−0.92	Silverton	6.50	3 stations	0.00
West Virginia	63.0	−3.0	Moorefield	99	8	Bayard	27	19	3.71	+0.85	Pickens	7.88	Bluefield	1.01
Wisconsin	57.5	−2.3	Osceola	94	5	Glen Flora	19	29	5.00	+1.14	Waupaca	8.34	Plum Island	0.95
Wyoming	50.8	−0.5	2 stations	97	3†	2 stations	7	28	0.45	−0.80	Encampment	1.75	Border	0.00

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes).............	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)..........	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes,* the accumulated amounts being recorded on successive lines until the excessive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk (*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading or (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available, and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REVIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observations, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction, t_0–t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind-direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

Chart IX.—Average values of pressure, temperature, and prevailing wind directions, and storm tracks over the North Atlantic Ocean, *for the corresponding month of last year.*

[Chart XLIV—121, illustrates text by Weightman, pp. 521-522; Charts XLIV—122 to 124, illustrate paper by W. G. Reed, p. 509.]

TABLE I.—*Climatological data for Weather Bureau stations, September, 1916.*

Districts and stations.	Elevation of instruments. Barometer above sea-level.	Thermometer above ground.	Anemometer above ground.	Pressure. Station, reduced to mean of 24 hours.	Sealevel, reduced to mean of 24 hours.	Departure from normal.	Temperature of the air. Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation. Total.	Departure from normal.	Days with 0.01 inch or more.	Wind. Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0–10	In.	In.
New England.							**60.8**	**+ 0.5**										**79**	**2.48**	**− 0.8**										**4.6**		
Eastport	76	67	85	29.93	30.01	−0.02	55.8	+ 0.6	79	14	64	41	20	48	27	52	49	82	2.41	− 0.6	9	6,091	s.	30	nw.	30	12	10	8	5.2	0	0
Greenville	1,070	6	....	28.85	30.02	....	56.2	....	81	13	66	35	11	46	37	....	....	....	4.23	....	10	....	....	....	....	....	....	....	....	....	0	0
Portland, Me	103	82	117	29.93	30.05	.00	58.8	− 0.8	83	14	67	42	26	51	27	54	50	76	1.47	− 1.7	11	5,857	s.	28	se.	29	15	6	9	4.6	0	0
Concord	288	70	79	29.73	30.04	− .02	59.2	+ 0.1	87	14	71	36	20	48	35	....	....	....	4.37	+ 1.2	8	3,412	se.	23	nw.	2	16	7	7	4.3	0	0
Burlington	404	11	48	29.58	30.01	− .05	60.2	+ 1.3	84	14	69	37	30	51	32	....	....	....	4.06	+ 0.7	12	8,516	s.	36	s.	21	7	11	12	5.9	0	0
Northfield	876	12	60	29.10	30.04	− .02	55.4	+ 0.8	85	14	68	32	26	43	43	52	49	81	3.00	+ 0.2	11	5,096	s.	26	s.	29	10	6	14	6.1	0	0
Boston	125	115	188	29.91	30.05	− .02	65.0	+ 2.3	90	14	74	44	30	56	28	58	55	74	1.90	− 1.3	8	6,934	sw.	31	s.	15	14	12	4	3.9	0	0
Nantucket	12	14	90	30.05	30.06	− .02	63.5	+ 0.7	82	14	70	49	12	57	22	59	56	83	1.44	− 1.3	7	10,354	sw.	35	n.	30	15	11	4	4.4	0	0
Block Island	26	11	46	30.03	30.06	− .02	63.3	− 0.8	81	8	69	44	30	57	18	60	57	82	0.82	− 2.2	8	10,596	sw.	48	nw.	19	18	4	8	4.2	0	0
Narragansett Pier	....	9	....	....	....	....	62.3	− 0.5	84	14	71	38	20	54	28	....	....	....	1.65	....	7	....	sw.	....	....	....	22	2	6	....	0	0
Providence	160	215	251	29.88	30.05	− .02	63.4	+ 0.2	88	8	73	43	12	54	28	58	55	78	0.86	− 2.3	10	8,463	sw.	36	nw.	30	14	12	4	4.2	0	0
Hartford	159	122	140	29.88	30.05	− .02	63.4	+ 1.7	89	8	74	42	17	53	34	58	55	79	3.46	0	8	5,376	s.	27	s.	28	15	9	6	4.3	0	0
New Haven	106	117	155	29.94	30.06	− .01	64.3	+ 0.4	91	8	74	43	30	55	28	58	54	73	2.54	− 1.2	8	6,526	s.	38	s.	29	15	12	3	3.7	0	0
Middle Atlantic States.							**65.9**	**− 0.7**										**73**	**3.12**	**− 0.1**										**4.0**		
Albany	97	102	115	29.93	30.04	−0.03	63.2	+ 0.9	86	14	73	39	30	54	30	56	52	71	3.96	+ 0.8	10	5,831	s.	29	se.	29	18	5	7	3.8	0	0
Binghamton	871	10	69	29.12	30.05	− .02	61.9	+ 1.9	87	14	74	35	30	50	37	....	....	....	4.05	+ 1.3	12	3,220	s.	20	n.	5	9	11	10	5.3	0	0
New York	314	414	454	29.73	30.06	− .02	66.0	− 0.5	89	8	74	44	30	58	24	59	54	72	2.98	− 0.6	9	11,703	s.	60	nw.	8	13	14	3	4.2	0	0
Harrisburg	374	94	104	29.69	30.09	+ .01	65.1	+ 0.2	89	8	75	43	30	55	28	57	52	70	6.50	+ 3.6	6	4,020	nw.	40	w.	8	16	8	6	3.9	0	0
Philadelphia	117	123	190	29.96	30.09	+ .01	68.5	+ 1.1	92	8	77	45	30	60	25	60	55	69	2.44	− 0.9	7	6,911	sw.	36	nw.	8	16	10	4	3.5	0	0
Reading	325	81	98	29.73	30.08	....	65.9	....	90	8	76	41	30	55	30	58	53	70	2.62	− 1.0	7	4,345	sw.	29	nw.	8	13	13	4	4.2	0	0
Scranton	805	111	119	29.22	30.07	.00	62.2	0.0	87	14	74	36	30	50	35	56	52	73	4.35	+ 1.5	10	4,306	sw.	24	n.	9	14	10	6	4.6	0	0
Atlantic City	52	37	48	30.03	30.08	+ .01	66.4	− 1.2	89	8	72	45	30	60	25	61	58	75	1.47	− 1.6	9	5,550	sw.	24	s.	29	15	10	5	3.7	0	0
Cape May	18	13	49	30.09	30.11	+ .04	66.5	− 2.5	90	8	74	44	30	59	22	62	....	....	5.29	+ 2.3	8	5,965	s.	30	nw.	29	16	10	4	3.7	0	0
Sandy Hook	22	10	57	30.04	30.06	....	67.0	....	90	8	74	49	30	60	22	60	57	74	1.29	....	7	11,834	s.	56	nw.	8	15	12	3	3.7	0	0
Trenton	190	159	183	29.86	30.06	....	66.1	....	92	8	76	41	30	56	29	58	55	75	2.51	− 1.1	7	7,575	s.	39	s.	29	12	14	4	4.3	0	0
Baltimore	123	100	113	29.96	30.09	+ .01	67.6	− 1.0	94	8	77	46	30	58	27	60	56	70	1.82	− 2.0	7	6,460	s.	44	nw.	8	13	12	5	3.7	0	0
Washington	112	62	85	29.96	30.08	.00	66.6	− 1.5	93	8	78	41	20	55	33	59	56	77	2.57	− 1.0	7	3,818	s.	26	n.	30	16	8	6	3.8	0	0
Lynchburg	681	153	188	29.35	30.09	+ .01	66.8	− 1.6	92	7	79	38	20	54	38	58	55	74	2.55	− 1.1	9	4,139	n.	35	n.	7	21	7	2	3.5	0	0
Norfolk	91	170	205	29.99	30.09	+ .03	70.3	− 1.4	90	8	77	49	30	64	26	63	59	72	3.53	− 0.5	9	8,440	ne.	46	w.	8	15	7	8	4.3	0	0
Richmond	144	11	52	29.94	30.09	+ .02	68.2	− 2.6	93	8	79	42	20	57	31	60	57	76	2.01	− 1.4	8	5,174	ne.	31	nw.	7	19	4	7	3.3	0	0
Wytheville	2,293	49	55	27.75	30.10	+ .03	61.4	− 2.2	86	7	73	34	20	50	40	56	53	84	3.03	− 0.3	8	3,096	nw.	23	sw.	28	15	10	5	3.9	0	0
South Atlantic States.							**72.2**	**− 0.8**										**77**	**2.92**	**− 1.8**										**3.9**		
Asheville	2,255	70	84	27.78	30.10	+0.03	63.9	− 1.1	88	7	75	40	30	53	36	56	54	78	1.72	− 1.3	8	4,682	nw.	31	e.	10	15	10	5	4.0	0	0
Charlotte	773	153	161	29.25	30.08	+ .01	70.0	− 0.7	93	7	79	45	20	61	25	61	56	68	0.88	− 2.3	5	6,946	ne.	28	nw.	8	16	11	3	3.2	0	0
Hatteras	11	12	50	30.05	30.06	.00	73.2	− 1.5	85	7	78	58	30	68	18	68	66	81	2.73	− 2.6	9	9,496	ne.	44	n.	29	12	4	1	3.9	0	0
Manteo	12	4	46	....	....	....	71.2	....	94	2	79	49	26	63	....	....	....	....	5.00	− 0.3	5	....	e.	....	....	....	19	5	6	....	0	0
Raleigh	376	103	110	29.69	30.08	+ .01	69.4	− 1.2	93	7	79	45	30	60	29	62	58	73	1.42	− 1.9	9	4,997	ne.	25	ne.	30	15	9	6	3.6	0	0
Wilmington	78	81	91	29.98	30.06	+ .01	72.0	− 1.1	92	7	81	51	30	64	27	66	64	83	4.57	− 0.7	8	5,035	ne.	26	ne.	5	15	7	8	4.1	0	0
Charleston	48	11	92	29.99	30.04	.00	75.1	− 1.1	89	7	82	54	30	68	23	69	66	78	2.76	− 2.7	8	7,455	ne.	31	ne.	10	19	9	2	3.0	0	0
Columbia, S. C	351	41	57	29.69	30.06	+ .01	73.0	− 0.7	92	7	83	48	21	63	34	64	59	70	2.23	− 1.2	6	4,654	ne.	22	ne.	12	15	11	4	3.6	0	0
Augusta	180	62	77	29.86	30.05	.00	74.1	− 0.3	93	6	84	51	21	64	32	66	63	77	3.45	− 0.3	5	3,742	ne.	20	ne.	11	16	9	5	3.6	0	0
Savannah	65	150	194	29.97	30.04	+ .01	75.2	− 0.2	91	6	83	54	30	67	26	68	66	79	2.10	− 3.5	7	7,360	ne.	35	e.	10	10	14	6	4.9	0	0
Jacksonville	43	209	245	29.96	30.01	+ .01	76.8	− 0.5	90	24	83	62	21	70	26	70	68	81	5.25	− 2.8	11	8,608	ne.	36	ne.	8	9	15	6	5.4	0	0
Florida Peninsula.							**80.5**	**− 0.5**										**78**	**4.52**	**− 2.8**										**5.2**		
Key West	22	10	64	29.91	29.93	−0.01	81.7	− 0.8	89	11	87	72	18	76	16	75	73	75	4.38	− 2.4	16	6,269	e.	35	sw.	15	9	16	5	4.8	0	0
Miami	25	71	79	29.93	29.96	....	79.6	− 1.9	86	17	85	70	30	74	15	74	72	79	4.81	− 4.8	20	5,641	e.	29	s.	14	6	11	13	6.2	0	0
Sand Key	23	39	72	29.89	29.92	− .02	81.0	....	87	17	84	71	15	78	15	76	74	77	2.59	....	13	8,670	e.	42	s.	13	10	16	4	4.5	0	0
Tampa	35	79	96	29.94	29.97	.00	79.6	+ 1.3	92	6	88	66	24	72	23	72	69	79	6.28	− 1.1	12	4,455	ne.	27	ne.	4	8	15	7	5.5	0	0
East Gulf States.							**74.6**	**0.0**										**74**	**2.83**	**− 0.9**										**3.4**		
Atlanta	1,174	190	216	28.85	30.07	+0.02	71.4	− 0.7	91	7	81	46	30	62	28	62	58	68	2.84	− 0.7	4	6,530	e.	36	nw.	29	19	6	5	3.7	0	0
Macon	370	78	87	29.66	30.05	+ .02	73.4	+ 0.5	93	7	84	48	30	63	31	65	62	73	2.51	− 0.9	6	3,962	ne.	25	nw.	29	19	6	5	3.3	0	0
Thomasville	273	49	58	29.72	30.01	.00	76.0	− 0.8	92	2	86	49	30	66	30	67	63	73	3.29	− 1.0	7	3,107	ne.	15	se.	9	15	9	6	4.1	0	0
Pensacola	56	140	182	29.95	30.01	+ .02	76.8	− 1.1	90	2	84	51	30	70	22	69	66	76	2.58	− 2.6	11	8,362	ne.	44	s.	10	14	10	6	4.1	0	0
Anniston	741	9	57	29.30	30.08	+ .05	72.0	+ 0.7	93	7	84	45	30	60	36	....	....	....	2.38	− 1.2	8	3,565	se.	20	e.	10	22	8	0	2.5	0	0
Birmingham	700	11	48	29.32	30.07	+ .04	73.6	− 0.4	94	7	85	44	30	62	32	63	60	73	2.63	− 0.9	9	4,266	n.	25	s.	10	16	10	4	3.5	0	0
Mobile	57	125	161	29.95	30.01	+ .01	77.0	+ 0.5	93	9	86	50	30	68	27	69	66	76	6.68	+ 1.7	9	6,653	n.	33	se.	9	14	11	5	3.7	0	0
Montgomery	223	100	112	29.80	30.04	+ .02	75.0	− 0.8	93	7	85	45	30	65	26	66	62	70	1.66	− 1.2	8	4,263	ne.	23	n.	2	15	13	2	3.5	0	0
Corinth	469	6	....	....	....	....	71.5	....	95	7	86	39	30	58	44	....	....	....	0.92	....	6	....	se.	....	....	....	14	11	5	....	0	0
Jackson	304	5	....	....	....	....	75.3	....	97	2	88	43	30	62	41	....	....	....	2.80	....	12	....	ne.	....	....	....	16	12	2	....	0	0
Meridian	375	85	93	29.64	30.03	+ .01	73.6	+ 0.9	92	2	85	44	30	62	36	65	62	74	1.48	− 2.0	6	3,397	ne.	19	ne.	24	23	6	1	2.3	0	0
Vicksburg	247	65	74	29.77	30.05	+ .03	74.4	− 0.4	92	10	84	45	30	65	26	66	63	77	3.88	+ 0.5	4	3,981	ne.	33	se.	25	22	5	3	2.8	0	0
New Orleans	51	76	84	29.95	30.00	+ .02	79.3	+ 1.3	94	9	87	56	30	72	22	71	68	75	3.13	− 1.7	10	4,030	ne.	22	ne.	29	15	12	3	3.5	0	0
West Gulf States.							**76.7**	**+ 0.6**										**69**	**2.44**	**− 1.0**										**3.4**		
Shreveport	249	77	93	29.76	30.02	+0.02	76.2	+ 0.5	95	4	87	46	30	65	32	66	61	68	1.46	− 1.8	4	4,359	s.	22	e.	11	19	9	2	3.1	0	0
Bentonville	1,303	11	44	28.68	30.03	+ .01	69.0	+ 0.1	93	5	81	34	29	57	35	....	....	....	4.34	+ 0.9	9	2,387	s.	23	s.	27	19	9	2	3.2	0	0
Fort Smith	457	79	94	29.54	30.01	.00	74.0	+ 1.3	96	5	85	43	29	63	31	64	59	67	3.61	+ 0.4	6	5,560	e.	41	nw.	27	18	10	2	3.1	0	0
Little Rock	357	139	147	29.67	30.04	+ .01	72.8	− 0.3	94	7	82	45	30	64	29	64	60	71	1.95	− 1.3	10	5,338	e.	50	nw.	21	17	8	5	3.3	0	0
Brownsville	57	3	40	....	....	....	80.0	....	93	28	88	57	30	71	26	....	....	....	3.21	....	11	....	se.	....	....	....	....	....	....	....	....	....
Corpus Christi	20	69	77	29.96	29.98	+ .03	79.4	+ 0.4	89	9	85	65	30	74	16	73	70	77	1.15	− 2.8	7	8,637	se.	36	ne.	29	8	16	6	5.0	0	0
Dallas	512	109	117	29.47	30.01	....	77.6	....	96	3	88	45	29	67	29	....	....	....	1.31	....	6	6,134	se.	31	n.	28	17	11	2	3.4	0	0
Forth Worth	670	106	114	29.28	29.98	− .01	77.4	+ 0.7	96	4	88	46	30	66	31	64	56	57	0.73	− 2.2	5	6,882	s.	35	n.	28	14	10	6	3.7	0	0
Galveston	54	106	114	29.95	30.01	+ .03	79.4	0.0	89	10	84	60	29	74	17	72	69	72	4.24	− 1.2	7	6,886	s.	33	n.	28	22	6	2	2.5	0	0
Houston	138	111	121	29.86	30.00	....	78.6	+ 0.1	94	8	88	51	30	70	24	....	....	....	2.45	....	6	4,642	se.	28	se.	25	14	14	2	3.3	0	0
Palestine	510	64	72	29.47	30.00	+ .01	77.0	+ 2.3	95	8	87	46	30	67	28	67	63	72	3.02	− 0.2	4	4,401	s.	26	se.	8	18	10	2	3.6	0	0
San Antonio	701	119	132	29.26	29.98	+ .03	78.0	+ 0.9	94	8	88	52	30	68	27	67	63	69	3.78	+ 0.8	7	4,866	sw.	40	ne.	25	20	9	1	2.9	0	0
Taylor	582	55	63	29.42	30.03	+ .06	77.2	+ 0.3	97	8	88	45	30	66	32	....	....	....	0.50	− 2.5	4	5,108	s.	25	nw.	28	10	19	1	4.2	0	0

TABLE I.—*Climatological data for Weather Bureau stations, September, 1916*—Continued.

Districts and stations.	Elevation of instruments. Barometer above sea-level.	Elevation of instruments. Thermometer above ground.	Elevation of instruments. Anemometer above ground.	Pressure. Station, reduced to mean of 24 hours.	Pressure. Sealevel, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature of the air. Mean max.+mean min.÷2.	Temperature of the air. Departure from normal.	Temperature of the air. Maximum.	Temperature of the air. Date.	Temperature of the air. Mean maximum.	Temperature of the air. Minimum.	Temperature of the air. Date.	Temperature of the air. Mean minimum.	Temperature of the air. Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Days with 0.01 inch or more.	Wind. Total movement.	Wind. Prevailing direction.	Wind. Maximum velocity. Miles per hour.	Wind. Maximum velocity. Direction.	Wind. Maximum velocity. Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
Ohio Valley and Tennessee.	Ft.	Ft.	Ft.	In.	In.	In.	°F. **66.6**	°F. **− 1.4**	°F.		°F.	°F.		°F.	°F.	°F.	°F.	% **70**	In. **2.72**	In. **0.0**		Miles.								0–10 **3.7**	In.	In.
Chattanooga	762	189	213	29.28	30.09	+0.03	70.9	− 0.3	92	7	81	46	30	61	32	61	56	66	1.62	− 1.6	7	4,835	s.	28	s.	8	17	11	2	3.8	0	0
Knoxville	996	93	100	29.04	30.08	+ .02	68.6	− 0.8	92	7	80	43	30	58	31	61	57	73	2.84	0	7	2,849	ne.	20	sw.	28	18	7	5	3.4	0	0
Memphis	399	76	97	29.66	30.08	+ .05	72.0	− 0.8	91	10	81	45	30	63	26	63	59	69	1.07	− 2.0	6	5,310	n.	32	nw.	28	19	6	5	3.3	0	0
Nashville	546	168	191	29.51	30.09	+ .03	69.2	− 2.3	92	6	80	42	30	58	37	60	56	68	1.92	− 1.8	7	5,680	ne.	45	nw.	22	19	6	5	3.3	0	0
Lexington	989	193	230	29.04	30.09	+ .02	66.7	− 1.2	89	7	76	39	30	57	28	....	....	....	2.75	+ 0.3	6	8,517	sw.	39	sw.	27	21	5	4	2.6	0	0
Louisville	525	219	255	29.51	30.09	+ .03	68.3	− 1.6	92	7	78	40	30	58	31	59	53	65	4.12	+ 1.5	6	7,554	s.	46	s.	27	19	5	6	3.1	0	0
Evansville	431	139	175	29.60	30.07	+ .01	69.4	− 0.3	92	6	80	41	30	59	30	61	56	70	2.57	− 0.1	4	7,305	s.	46	s.	27	16	11	3	3.6	0	0
Indianapolis	822	194	230	29.19	30.07	+ .01	65.4	− 1.3	90	7	76	39	30	55	29	56	50	65	2.26	− 0.8	8	8,227	s.	46	sw.	27	14	11	5	3.9	0	0
Terre Haute	575	96	129	29.43	30.05	......	65.9	......	92	6	77	38	30	55	33	57	52	68	1.24	......	8	6,755	s.	46	s.	27	9	18	3	5.0	0	0
Cincinnati	628	11	51	29.40	30.08	+ .01	65.2	+ 0.5	90	7	76	36	30	54	33	57	52	69	3.29	+ 1.0	9	4,627	s.	28	sw.	27	19	7	4	3.6	0	0
Columbus	824	173	222	29.21	30.08	+ .01	63.9	− 2.0	90	7	75	35	30	53	31	55	50	67	1.54	− 1.0	9	7,597	sw.	42	w.	6	17	6	7	3.5	0	0
Dayton	899	181	216	29.10	30.05	......	64.4	− 3.0	91	7	75	36	30	54	32	56	52	71	5.90	+ 3.4	10	6,914	sw.	39	sw.	27	16	10	4	3.8	0	0
Pittsburgh	842	353	410	29.17	30.07	− .01	64.2	− 1.9	87	6	74	38	19	55	28	56	50	66	1.63	− 0.8	9	7,591	sw.	32	sw.	21	13	9	8	4.4	0	0
Elkins	1,940	41	50	28.08	30.12	+ .04	60.3	− 1.6	86	6	74	31	30	46	43	53	51	86	4.87	+ 2.0	9	2,166	w.	22	w.	8	13	9	8	4.5	0	0
Parkersburg	638	77	84	29.44	30.10	+ .02	64.2	− 1.9	90	7	76	35	30	53	35	57	54	76	3.18	+ 0.5	11	3,567	se.	19	nw.	28	17	8	5	4.1	0	0
Lower Lake Region.							**62.9**	**− 0.2**										**68**	**2.56**	**− 0.2**										**5.1**		
Buffalo	767	247	280	29.20	30.02	−0.04	62.0	− 0.9	80	27	68	38	30	56	22	56	51	69	1.38	− 1.8	11	12,271	sw.	50	sw.	8	11	6	13	5.5	0	0
Canton	448	10	61	29.51	29.98	......	60.1	+ 0.8	86	7	70	31	30	50	32	....	....	....	3.42	+ 0.6	13	7,259	sw.	32	sw.	29	9	10	11	5.6	0	0
Oswego	335	76	91	29.65	30.01	− .05	62.8	+ 0.1	90	7	71	38	30	55	27	55	51	70	1.98	− 0.8	15	7,032	s.	26	sw.	21	8	13	9	5.3	0	0
Rochester	523	97	113	29.47	30.04	− .02	62.8	+ 0.9	90	7	72	36	30	54	30	55	50	68	1.01	− 1.3	12	5,535	sw.	26	w.	16	12	7	11	5.1	0	0
Syracuse	597	97	113	29.40	30.05	− .02	62.2	+ 0.6	87	7	71	36	30	54	28	55	51	72	4.12	+ 1.3	15	7,673	s.	29	sw.	23	8	15	7	5.4	0	0
Erie	714	130	116	29.27	30.03	− .03	63.3	− 0.6	88	7	71	40	30	56	27	56	52	69	4.47	+ 1.0	15	10,244	s.	54	sw.	7	9	11	10	5.4	0	0
Cleveland	762	190	201	29.23	30.05	− .01	63.7	− 0.6	92	7	72	41	19	56	31	56	52	71	2.84	− 0.4	11	9,970	s.	42	w.	7	9	14	7	5.0	0	0
Sandusky	629	62	103	29.36	30.04	− .02	64.6	− 0.7	95	7	73	41	16	56	36	56	50	64	2.03	− 0.6	8	8,466	sw.	42	nw.	7	9	14	7	5.0	0	0
Toledo	628	208	243	29.37	30.05	− .01	64.8	+ 0.7	92	7	74	40	30	56	31	55	49	61	2.16	− 0.2	10	9,831	sw.	48	sw.	7	14	12	4	4.0	0	0
Fort Wayne	856	113	124	29.13	30.05	......	62.8	− 2.7	91	7	74	34	30	52	34	55	49	66	1.96	......	9	6,483	sw.	40	sw.	27	11	13	6	4.9	0	0
Detroit	730	218	245	29.25	30.04	− .02	63.1	0.0	90	7	71	38	30	55	24	55	50	68	2.74	+ 0.3	7	7,565	sw.	68	nw.	7	9	15	6	4.9	0	0
Upper Lake Region.							**58.2**	**− 1.2**										**76**	**3.82**	**+ 0.7**										**5.9**		
Alpena	609	13	92	29.22	29.99	−0.04	56.9	− 0.4	85	12	66	29	30	48	29	52	50	81	1.50	− 2.0	11	8,196	nw.	35	w.	15	6	14	10	5.5	T.	0
Escanaba	612	54	60	29.30	29.96	− .05	54.0	− 2.9	72	11	61	32	29	47	24	50	48	81	5.07	+ 1.5	15	5,969	s.	31	s.	30	8	6	16	6.2	0	0
Grand Haven	632	54	92	29.32	30.00	− .04	60.0	− 1.1	81	11	68	35	30	52	31	54	50	73	4.28	+ 1.1	14	8,219	s.	37	n.	4	13	7	10	4.8	0	0
Grand Rapids	707	70	87	29.25	30.02	− .03	61.4	− 0.4	87	12	70	37	30	52	31	54	50	72	2.43	− 0.7	12	4,053	s.	20	nw.	4	5	12	13	6.2	0	0
Houghton	684	62	99	29.20	29.92	− .08	54.5	− 1.6	77	9	61	37	28	48	28	....	....	....	6.17	+ 2.6	18	6,750	e.	35	nw.	3	6	6	18	7.1	0.3	0
Lansing	878	11	62	29.08	30.02	......	60.4	− 0.9	88	7	72	30	19	48	39	53	49	75	2.17	− 0.4	10	3,916	sw.	20	sw.	27	8	15	7	5.4	0	0
Ludington	637	60	66	29.30	29.99	......	58.2	......	76	6	65	38	29	52	28	54	50	76	2.95	......	14	7,916	s.	34	s.	20	11	7	12	5.3	0	0
Marquette	734	77	111	29.16	29.97	− .03	55.1	− 1.7	78	9	62	35	28	48	25	50	47	78	5.74	+ 2.2	16	7,741	w.	37	s.	30	5	7	18	7.1	T.	0
Port Huron	638	70	120	29.32	30.01	− .05	60.8	− 0.1	91	7	70	31	30	52	30	55	50	71	1.23	− 1.4	8	7,784	sw.	30	sw.	22	10	14	6	5.0	0	0
Saginaw	641	48	82	29.32	30.01	......	60.8	......	90	6	72	32	30	50	33	53	49	71	1.51	− 1.6	9	6,367	s.	29	s.	27	6	12	12	6.2	0	0
Sault Sainte Marie	614	11	61	29.28	29.97	− .05	54.4	+ 0.1	77	9	62	32	30	47	29	51	48	86	9.35	+ 5.9	20	6,107	nw.	29	nw.	17	4	6	20	7.8	0	0
Chicago	823	140	310	29.15	30.03	− .01	64.4	− 0.2	89	7	72	39	29	56	26	56	50	64	2.24	− 0.8	8	8,839	sw.	37	nw.	5	14	7	9	4.3	0	0
Green Bay	617	109	144	29.30	29.96	− .06	58.2	− 0.9	83	6	67	33	16	50	29	53	49	77	3.2[illegible]	+ 0.2	13	7,641	sw.	43	w.	5	6	10	14	6.5	0	0
Milwaukee	681	119	133	29.26	30.00	− .03	60.2	− 1.3	87	11	68	36	29	52	29	53	49	74	5.21	+ 2.3	11	6,772	sw.	30	s.	20	16	3	11	4.7	0	0
Duluth	1,133	11	47	28.73	29.95	− .03	53.0	− 3.7	76	19	62	30	29	44	30	47	45	81	4.25	+ 0.7	10	8,678	sw.	36	w.	14	6	8	16	7.1	T.	0
North Dakota.							**55.4**	**− 1.6**										**72**	**1.30**	**− 0.1**										**4.4**		
Moorhead	940	8	57	28.92	29.93	−0.03	56.4	− 0.2	90	3	67	29	29	46	42	51	48	85	2.46	+ 0.2	12	5,742	nw.	32	se.	9	14	9	7	4.2	0	0
Bismarck	1,674	8	57	28.17	29.95	+ .01	56.8	− 0.3	93	3	70	24	15	44	48	48	42	68	0.70	− 0.5	8	6,955	nw.	40	nw.	20	15	9	6	4.1	0	0
Devils Lake	1,482	11	44	28.31	29.88	− .06	55.0	− 0.6	92	3	67	24	15	43	42	47	41	68	0.89	− 0.5	9	7,647	sw.	38	nw.	20	13	8	9	4.8	T.	0
Grand Forks	835	12	89	......	......	......	54.8	......	89	3	67	28	17	43	41	49	....	....	1.19	......	9	......	se.	38	sw.	10	11	11	8	....	0	0
Williston	1,872	41	48	27.93	29.91	− .02	54.2	− 5.3	90	3	67	28	22	41	40	46	41	68	1.26	+ 0.4	7	6,453	w.	39	w.	30	12	11	7	4.7	0	0
Upper Mississippi Valley.							**62.8**	**− 1.3**										**73**	**3.71**	**+ 0.2**										**4.7**		
Minneapolis	918	10	208	28.96	29.93	......	59.8	......	91	5	69	35	29	50	31	....	....	....	2.42	− 1.2	13	7,986	s.	36	s.	10	8	6	16	6.5	0	0
St. Paul	837	201	236	29.04	29.95	−0.04	59.2	− 1.1	90	5	68	33	29	50	33	....	....	....	1.81	− 1.6	13	8,397	nw.	45	s.	10	9	14	7	5.2	T.	0
La Crosse	714	11	48	29.20	29.97	− .04	59.7	− 2.0	90	6	70	31	29	50	35	....	....	....	4.75	+ 0.6	11	3,223	s.	20	w.	20	9	6	15	6.2	0	0
Madison	974	70	78	28.97	30.00	− .03	59.4	− 1.7	85	6	68	33	16	51	28	54	50	74	5.73	+ 2.6	13	6,568	s.	28	sw.	26	8	9	13	5.9	0	0
Wausau	1,247	4	....	28.64	29.97	......	55.2	......	80	6	65	28	18	46	34	....	....	....	5.99	......	17	......	se.	....	......	....	8	8	14	6.2	T.	0
Charles City	1,015	10	49	28.91	29.98	− .02	59.5	− 2.2	90	4	71	29	29	48	38	53	51	81	6.19	+ 3.4	13	4,746	nw.	48	nw.	6	8	14	8	5.5	0	0
Davenport	606	71	79	29.35	30.01	− .02	64.0	− 0.7	92	5	74	33	29	53	32	56	51	71	2.82	− 0.3	10	5,286	sw.	27	w.	21	15	8	7	4.2	0	0
Des Moines	861	84	97	29.08	29.98	− .04	64.3	− 0.7	94	5	75	31	29	53	34	56	50	56	1.72	− 1.4	7	5,555	sw.	35	sw.	16	15	8	7	4.0	0	0
Dubuque	698	81	96	29.27	30.02	− .01	62.2	− 1.4	89	4	72	35	29	52	33	55	51	72	6.19	+ 2.6	12	4,452	s.	24	sw.	5	11	14	5	4.6	0	0
Keokuk	614	64	78	29.35	30.02	− .01	65.2	− 1.2	93	5	76	34	29	55	33	58	55	75	3.41	− 0.6	6	5,275	s.	29	sw.	21	18	9	3	3.3	0	0
Cairo	356	87	93	29.67	30.04	− .01	69.6	− 0.6	92	6	79	43	29	60	29	62	58	74	2.07	− 0.4	7	5,503	s.	36	w.	27	16	10	4	3.6	0	0
Peoria	609	11	45	29.38	30.05	+ .01	63.6	− 0.7	94	5	75	34	29	52	35	56	53	77	3.73	+ 0.6	6	4,321	s.	25	ne.	5	16	10	4	3.6	0	0
Springfield, Ill	644	10	91	29.36	30.03	− .02	65.7	− 0.7	93	5	76	38	29	55	32	57	52	71	3.35	0.0	8	5,724	s.	29	nw.	5	11	14	5	4.5	0	0
Hannibal	534	74	109	29.47	30.04	+ .01	66.2	− 1.7	94	5	77	35	29	55	36	....	....	....	2.77	− 0.8	7	5,981	sw.	28	sw.	20	18	7	5	3.3	0	0
St. Louis	567	265	303	29.44	30.04	.00	68.3	− 1.7	94	5	77	41	29	59	25	60	56	70	2.69	− 0.2	5	8,922	s.	56	s.	27	19	5	6	3.5	0	0
Missouri Valley.							**64.8**	**− 0.5**										**67**	**2.48**	**− 0.2**										**3.5**		
Columbia, Mo	781	11	84	29.21	30.04	+0.01	66.8	− 1.0	96	5	78	34	29	55	36	....	....	....	4.43	+ 1.6	4	4,855	s.	28	w.	28	15	6	9	4.1	0	0
Kansas City	963	161	181	28.98	30.00	− .02	67.8	+ 0.3	95	5	77	39	29	58	28	58	53	65	4.96	+ 1.2	8	7,929	s.	41	s.	26	20	8	2	2.9	0	0
St. Joseph	967	11	49	28.97	30.00	......	67.3	......	97	5	78	33	29	56	33	58	53	68	3.51	......	6	5,777	se.	28	nw.	28	17	8	5	3.4	0	0
Springfield, Mo	1,324	98	104	28.66	30.05	+ .02	68.2	+ 0.3	92	5	79	35	29	57	30	58	53	66	1.19	− 2.6	7	7,210	s.	34	s.	27	19	9	2	2.8	0	0
Iola	984	11	50	28.98	30.01	.00	68.4	− 0.2	95	5	80	32	29	57	34	....	....	....	5.56	+ 2.2	9	4,370	s.	24	sw.	26	18	9	3	3.0	0	0
Topeka	983	85	101	......	......	......	68.2	− 0.1	97	5	79	34	29	57	33	....	....	....	2.03	− 1.5	6	7,281	s.	35	w.	7	16	10	4	3.5	0	0
Drexel	1,299	10	53	28.60	29.98	......	63.5	......	92	6	76	28	29	51	36	55	51	73	0.75	......	4	7,340	s.	33	sw.	6	15	10	5	3.9	....	....
Lincoln	1,189	11	84	28.72	29.97	− .02	65.3	+ 0.1	97	4	78	29	29	53	37	55	49	65	1.03	− 1.6	5	7,556	s.	40	n.	28	17	10	3	3.4	0	0
Omaha	1,105	115	122	28.82	29.98	− .02	65.4	− 0.4	95	6	76	34	29	55	32	56	50	66	1.76	− 1.3	6	5,737	s.	29	nw.	28	15	11	4	3.8	0	0
Valentine	2,598	47	54	27.28	29.98	+ .02	60.2	− 2.1	93	1	75	28	15	45	53	50	43	64	0.32	− 1.5	7	6,821	nw.	36	s.	8	21	7	2	3.1	0	0
Sioux City	1,135	94	164	28.76	29.97	− .01	62.2	− 1.9	96	4	73	31	29	51	36	55	51	73	3.41	+ 0.9	12	8,961	s.	47	nw.	4	17	10	3	3.4	0	0
Huron	1,306	59	74	28.57	29.97	+ .01	59.2	− 0.4	89	4	72	28	15	46	46	51	47	73	1.78	+ 0.1	7	8,106	se.	42	nw.	7	13	11	6	4.5	0	0
Pierre	1,572	70	75	28.30	29.96	+ .01	62.2	− 0.6	93	3	75	31	15	49	54	52	45	61	1.06	0	5	6,618	nw.	47	n.	6	18	8	4	2.9	0	0
Yankton	1,233	49	57	28.64	29.95	− .03	62.8	− 0.5	98	4	75	32	29	51	40	....	....	....	2.89	+ 0.4	9	5,716	se.	36	nw.	13	10	15	5	4.7	0	0

TABLE I.—*Climatological data for Weather Bureau stations, September, 1916*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea-level.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sealevel, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max.+mean min.÷2.	Temperature of the air: Departure from normal.	Temperature of the air: Maximum.	Temperature of the air: Date.	Temperature of the air: Mean maximum.	Temperature of the air: Minimum.	Temperature of the air: Date.	Temperature of the air: Mean minimum.	Temperature of the air: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with 0.01 inch or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
Northern Slope.							**56.2**	**− 1.1**										**57**	**0.95**	**− 0.2**										**3.6**		
Billings	3,140	5					55.6		94	8	73	23	28	38	56				1.15								14	12	4			
Havre	2,505	11	44	27.31	29.93	−0.01	55.4	− 2.2	86	2	69	26	28	42	44	48	42	69	1.42	+ 0.4	12	5,505	sw.	36	sw.	3	16	6	8	4.5	0	
Helena	4,110	87	114	25.82	29.98	+ .01	55.2	− 1.0	92	2	68	28	28	43	39	45	38	58	1.69	+ 0.6	8	6,411	sw.	45	sw.	26	10	10	10	4.9	T.	0
Kalispell	2,962	11	34	26.93	29.97	+ .01	53.0	− 0.9	85	2	66	29	14	40	39	46	40	67	1.63	+ 0.3	8	3,159	w.	24	e.	2	12	11	7	4.4	0	0
Miles City	2,371	26	48	27.45	29.98	+ .03	60.8	− 0.4	102	2	75	34	15	46	46	50	44	66	1.35	+ 0.4	7	4,016	n.	28	w.	4	20	8	2	3.0	0	0
Rapid City	3,259	50	58	26.60	29.99	+ .03	59.6	+ 0.5	95	3	74	33	14	45	40	47	34	45	0.07	− 1.2	5	6,450	w.	40	n.	13	21	5	4	2.8	0	0
Cheyenne	6,088	84	101	24.06	29.96	.00	55.8	− 1.4	83	8	70	26	28	42	37	44	34	51	1.00	+ 0.1	5	8,557	nw.	46	nw.	27	18	6	6	3.5	T.	0
Lander	5,372	60	68	24.68	29.98	+ .02	55.6	+ 0.4	89	2	74	28	28	38	46	42	28	42	0.13	− 0.9	3	3,833	sw.	32	n.	26	20	7	3	3.1	T.	0
Sheridan	3,790	10	47	26.11	29.99		55.2		95	2	73	25	15	37	51	43	34	57	0.56		6	3,629	nw.	40	nw.	27	21	6	3	2.9	T.	0
Yellowstone	6,200	11	48	23.93	30.01	+ .04	49.0	− 4.4	80	1	64	21	14	34	44	38	28	51	0.71	− 0.3	8	5,541	s.	42	sw.	2	12	10	8	4.4	1.1	0
North Platte	2,821	11	51	27.10	30.00	+ .03	62.8	− 0.4	94	4	78	30	29	48	52	51	45	63	0.70	− 0.8	5	4,589	s.	30	n.	13	20	5	5	2.9	0	0
Middle Slope.							**68.6**	**− 0.8**										**59**	**1.61**	**− 0.6**										**3.2**		
Denver	5,292	106	113	24.78	29.97	+0.01	61.4	− 1.3	90	8	76	33	29	47	45	47	36	47	0.80	− 0.1	8	5,169	se.	32	nw.	27	16	10	4	3.2	0	0
Pueblo	4,685	80	86	25.32	29.96	.00	63.2	− 1.2	92	4	79	30	29	48	48	48	39	49	T.	− 0.6	0	4,452	nw.	33	nw.	5	23	7	0	2.1	0	0
Concordia	1,392	50	58	28.54	30.00	+ .01	67.2	− 0.9	100	5	80	32	29	55	35	56	50	63	2.70	+ 0.1	5	6,027	s.	32	e.	7	12	14	4	4.1	0	0
Dodge	2,509	11	51	27.43	30.00	+ .02	67.0	− 1.2	96	4	80	34	29	54	38	56	50	67	1.15	− 0.6	7	7,507	s.	35	se.	9	13	16	1	3.8	0	0
Wichita	1,358	139	158	28.56	29.97	− .03	69.3	− 0.5	94	10	80	39	29	58	31	59	52	61	0.86	− 2.3	6	9,536	s.	48	s.	26	14	15	1	3.1	0	0
Altus	1,410	5	0				74.2		98	10	88	40	29	61	38				3.27		6		se.				21	4	5		0	0
Muskogee	652	4					74.5		100	5	88	36	29	61	36				1.56		6		s.				23	4	3		0	0
Oklahoma	1,214	10	47	28.74	30.00	+ .01	72.2	+ 0.1	94	7	84	39	29	60	32	61	56	67	2.54	− 0.2	8	9,250	s.	43	n.	28	20	9	1	2.6	0	0
Southern Slope.							**72.1**	**− 0.7**										**61**	**1.28**	**− 1.3**										**3.1**		
Abilene	1,738	10	52	28.19	29.97	+0.01	75.6	+ 1.4	97	9	88	44	29	64	34	61	53	55	0.88	− 2.3	4	6,982	s.	32	ne.	28	20	5	5	3.2	0	0
Amarillo	3,676	10	49	26.30	29.98	+ .02	67.8	+ 0.1	91	10	81	40	29	55	38	57	52	66	1.76	− 0.6	8	8,174	s.	35	n.	14	18	12	0	2.7	0	0
Del Rio	944	64	71	28.97	29.94	.00	76.7	− 2.2	91	9	84	54	30	69	25				2.11	− 0.4	7	6,140	se.	29	n.	12	17	11	2	3.4	0	0
Roswell	3,566	75	85	26.39	29.95	+ .03	68.2	− 2.1	89	26	82	41	29	55	43	57	50	63	0.37	− 1.9	3	4,615	s.	39	nw.	10	15	15	0	3.0	0	0
Southern Plateau.							**70.0**	**− 0.6**										**47**	**0.92**	**− 0.1**										**2.4**		
El Paso	3,762	110	133	26.20	29.88	0.00	73.0	+ 0.3	90	22	84	50	29	62	32	58	48	50	0.55	− 0.9	5	6,997	e.	35	e.	28	21	6	3	2.8	0	0
Santa Fe	7,013	57	66	23.33	29.91	− .02	60.8	+ 0.2	82	7	72	39	29	49	31	48	55	53	1.45	− 0.2	9	4,975	e.	26	nw.	18	13	16	1	3.8	0	0
Flagstaff	6,908	8	57	23.43	29.92	+ .03	55.4	− 0.1	77	7	71	30	24	40	43	45			1.78		11		w.	38	sw.	22	18	10	2			
Phoenix	1,108	76	81	28.69	29.81	.00	80.9	− 0.5	104	1	95	55	28	67	40	66	58	52	1.66	+ 0.6	4	3,345	e.	27	se.	4	25	1	4	2.0	0	0
Yuma	141	9	54	29.63	29.77	− .01	84.0	+ 0.1	109	1	99	59	26	69	44	67	57	48	0.01	− 0.2	1	3,361	sw.	25	sw.	19	23	4	3	2.2	0	0
Independence	3,910	11	42	25.96	29.90	+ .04	65.6	− 3.5	90	1	83	38	12	48	46	50	32	33	0.07	0	1	4,206	se.	33	se.	2	26	2	2	1.2	0	0
Middle Plateau.							**62.6**	**0.0**										**37**	**0.42**	**− 0.2**										**1.8**		
Reno	4,532	74	81	25.48	29.92	−0.03	61.7	+ 2.0	89	14	79	33	11	44	46	46	32	41	0.35	+ 0.1	3	4,261	w.	32	w.	2	24	4	2	1.5	0	0
Tonopah	6,090	12	20	24.11	29.92		63.4		82	1	74	39	11	53	30	45	27	29	0.17	− 0.3	3	6,193	se.	34	nw.	9	26	3	1	1.1	0	0
Winnemucca	4,344	18	56	25.62	29.98	+ .05	59.1	− 1.4	92	1	79	26	11	39	55	43	28	39	0.26	− 0.1	1	3,958	ne.	28	sw.	2	27	1	2	1.4	0	0
Modena	5,479	10	43	24.65	29.93	+ .01	60.4	+ 0.2	85	13	78	32	11	42	47	44	28	37	0.71	− 0.4	4	7,658	w.	52	sw.	17	21	9	0	2.5	0	0
Salt Lake City	4,360	147	189	25.62	29.93	− .02	65.3	+ 0.2	90	1	77	39	11	54	32	49	35	36	0.50	− 0.4	2	5,369	se.	42	w.	22	20	8	2	2.0	0	0
Grand Junction	4,602	82	96	25.40	29.94	− .01	65.5	− 0.9	88	4	79	42	28	52	35	49	36	39	0.50	− 0.4	4	5,538	se.	37	sw.	5	19	10	1	2.6	0	0
Northern Plateau.							**60.8**	**− 0.4**										**45**	**0.25**	**− 0.5**										**3.4**		
Baker	3,471	48	53	26.46	30.03	+0.04	55.6	− 1.4	88	1	71	31	28	40	42	45	36	53	0.28	− 0.5	5	4,458	se.	18	nw.	22	19	5	6	3.0	0	0
Boise	2,739	78	86	27.16	29.99	+ .02	62.5	+ 0.6	95	1	77	37	10	48	38	49	35	40	0.05	− 0.4	1	3,418	nw.	22	w.	9	21	5	4	2.5	0	0
Lewiston	757	40	48	29.18	29.99	+ .01	63.0	− 0.5	96	1	78	36	28	48	45				0.45	− 0.2	6	2,021	e.	22	w.	7	17	5	8	3.8	0	0
Pocatello	4,477	60	68	25.48	29.94	− .02	60.2	− 0.5	90	1	75	29	28	45	42	45	29	35	0.01	− 0.9	1	6,311	se.	44	sw.	3	17	11	2	2.9	0	0
Spokane	1,929	101	110	27.95	29.99	+ .01	59.6	+ 0.8	90	1	73	35	28	47	41	48	37	52	0.56	− 0.4	6	4,049	ne.	29	sw.	26	14	7	9	4.5	0	0
Walla Walla	991	57	65	28.92	29.99	− .01	64.2	− 1.2	92	1	76	40	28	52	34	53	43	47	0.15	− 0.8	5	3,351	s.	28	w.	26	17	6	7	3.8	0	0
North Pacific Coast Region.							**59.9**	**+ 1.1**										**76**	**0.66**	**− 1.8**										**4.9**		
North Head	211	11	56	29.83	30.05	+0.02	56.7	+ 0.5	80	14	61	45	30	52	23	54	51	87	1.29	− 0.6	7	8,869	nw.	38	nw.	30	11	8	11	5.2	0	0
North Yakima	1,076	4					61.8		88	1	76	35	28	48	38				0.19		2		nw.				22	6	2		0	0
Seattle	125	215	250	29.93	30.06	+ .05	58.8	+ 0.9	78	15	67	44	29	51	28	53	48	72	0.70	− 1.2	5	5,046	n.	30	sw.	3	10	9	11	5.2	0	0
Tacoma	213	113	120	29.84	30.06	+ .04	58.6	+ 1.0	80	15	68	43	27	50	33	54	50	74	0.50	− 2.0	3	3,944	n.	26	ne.	13	11	11	8	5.1	0	0
Tatoosh Island	109	7	57	29.95	30.05	+ .04	53.4	+ 0.4	73	14	58	44	30	48	24	51	49	88	0.97	− 5.2	8	8,196	s.	49	ne.	14	13	7	10	4.5	0	0
Medford	1,425	4	80				64.8		96	14	84	36	26	46	51				0.37		4		e.				17	4	9		0	0
Portland, Oreg.	153	68	106	29.87	30.03	.00	62.5	+ 1.9	85	15	72	45	30	53	34	55	49	65	0.71	− 1.1	4	3,711	nw.	25	ne.	14	8	12	10	5.4	0	0
Roseburg	510	9	57	29.48	30.03	+ .01	62.6	+ 2.1	93	15	76	42	28	49	44	55	49	68	0.59	− 0.4	5	1,746	n.	12	n.	30	15	10	5	3.8	0	0
Middle Pacific Coast Region.							**63.9**	**+ 0.5**										**60**	**0.89**	**+ 0.1**										**3.1**		
Eureka	62	73	89	29.95	30.02	+0.01	55.8	+ 0.9	75	11	61	44	20	50	26	53	50	85	0.38	− 0.7	3	4,150	n.	39	n.	26	11	9	10	5.1	0	0
Mount Tamalpais	2,375	11	18	27.53	29.97	+ .03	65.6	− 0.5	89	14	73	46	25	58	23	51	39	47	1.29	+ 0.7	4	10,735	w.	72	nw.	8	23	4	3	2.0	0	0
Point Reyes Light	490	7	18	29.42	29.93		55.8	− 0.3	80	27	61	45	12	51	27				2.36		4	13,106	nw.	64	nw.	8	10	9	11	5.7	0	0
Red Bluff	332	50	56	29.55	29.90	− .03	73.1	− 0.8	98	19	87	48	17	59	42	56	40	37	0.08	− 0.7	2	3,898	se.	30	nw.	26	24	4	2	1.7	0	0
Sacramento	69	106	117	29.84	29.91	+ .02	70.2	+ 1.1	96	13	85	48	24	56	38	57	46	53	0.16	− 0.2	2	5,590	s.	29	n.	26	24	3	3	1.5	0	0
San Francisco	155	209	213	29.79	29.96	+ .02	62.2	+ 2.9	87	27	71	50	20	54	31	55	52	79	1.20	+ 0.9	3	6,132	sw.	32	sw.	29	18	7	5	3.3	0	0
San Jose	141	12	110	29.82	29.97		64.8	+ 0.1	93	13	79	44	18	51	42				0.78	+ 0.4	2	3,715	nw.	24	s.	30	22	5	3	2.5	0	0
South Pacific Coast Region.							**66.5**	**− 0.8**										**71**	**0.84**	**+ 0.6**										**2.9**		
Fresno	327	89	98	29.54	29.89	+0.02	73.2	− 1.1	100	15	88	52	26	58	39	57	44	42	0.38	+ 0.1	2	5,504	nw.	32	nw.	21	26	3	1	1.0	0	0
Los Angeles	338	159	191	29.56	29.92	+ .04	65.2	− 1.3	83	29	74	53	8	56	27	58	55	80	0.77	+ 0.7	1	3,458	sw.	14	sw.	22	19	8	3	3.3	0	0
San Diego	87	62	70	29.82	29.91	+ .02	64.4	− 2.5	80	29	69	56	14	60	15	60	59	87	0.25	+ 0.2	1	4,199	nw.	19	nw.	12	14	13	3	4.2	0	0
San Luis Obispo	201	32	40	29.74	29.96	+ .03	63.3	+ 1.8	96	13	76	45	10	50	42	56	52	76	1.94	+ 1.5	2	2,685	nw.	22	w.	25	18	9	3	3.1	0	0
West Indies.																																
San Juan, P. R.	82	8	54	29.85	29.93	−0.01	80.0		89	12	85	72	5	75	16				8.52	+ 1.7	20	5,958	se.	44	e.	5	5	17	8	5.6	0	0
Panama.																																
Balboa Heights	118	7	97	29.74	29.86		79.4		90	13	85	71	17	73	18	75	74	91	8.02	+ 0.4	21	4,207	nw.	29	ne.	16	0	7	23	8.2	0	0
Colon	25	5	71	29.83	29.86		80.8		90	20	87	74	17	75	16	76	74	87	10.41	− 2.1	25	4,881	se.	31	ne.	3	0	7	23	8.4	0	0

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during September, 1916, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abeline, Tex.	1-2			0.51														.32			
Albany, N. Y.	15	D. N. a. m.	12:50 p. m.	2.06	3:31 a. m.	4:49 a. m.	0.11	0.09	0.21	0.35	0.42	0.51	0.63	0.79	0.96	1.00	1.05	1.10	1.42		
Alpena, Mich.	[1]31-1			0.57														0.17			
Amarillo, Tex.	23-24			0.99														0.72			
Anniston, Ala.	28	3:08 p. m.	5:20 p. m.	1.26	4:12 p. m.	4:57 p. m.	0.11	0.17	0.43	0.47	0.48	0.53	0.70	0.79	0.86	1.14					
Asheville, N. C.	28	7:35 p. m.	11:25 p. m.	1.14	8:01 p. m.	8:23 p. m.	0.15	0.12	0.29	0.44	0.52	0.55									
Atlanta, Ga.	28	5:55 p. m.	8:35 p. m.	1.45	6:54 p. m.	8:00 p. m.	0.06	0.10	0.27	0.38	0.42	0.55	0.69	0.83	0.99	1.07	1.16	1.26	1.39		
Atlantic City, N. J.	15			0.35														0.24			
Augusta, Ga.	14	6:50 p. m.	D. N. p. m.	2.09	7:41 p. m.	8:21 p. m.	0.05	0.16	0.36	0.52	0.70	0.89	1.00	1.08	1.20	1.22					
					9:59 p. m.	10:07 p. m.	1.72	0.20	0.33												
Baker, Oreg.	2			0.07														0.04			
Baltimore, Md.	22			0.54														0.37			
Bentonville, Ark.	[1]31-1	11:20 p. m.	7:40 a. m.	1.08	6:26 a. m.	7:01 a. m.	0.33	0.09	0.17	0.28	0.40	0.55	0.63	0.72							
	1	7:10 p. m.	7:50 p. m.	0.50	7:15 p. m.	7:37 p. m.	0.01	0.08	0.20	0.36	0.46	0.49									
	27	5:40 p. m.	7:25 p. m.	0.87	5:47 p. m.	6:07 p. m.	0.01	0.28	0.55	0.67	0.72										
Binghamton, N. Y.	14-15			1.34														0.61			
Birmingham, Ala.	18	12:41 p. m.	2:15 p. m.	0.75	12:47 p. m.	12:58 p. m.	0.01	0.21	0.39	0.40											
Bismarck, N. Dak.	24-25			0.14														0.13			
Block Island, R. I.	8-9			0.43														0.36			
Boise, Idaho	9			0.05														0.04			
Boston, Mass.	5-6			0.62														0.23			
Buffalo, N. Y.	7-8			0.65														0.49			
Burlington, Vt.	29	11:00 a. m.	11:50 a. m.	0.59	11:09 a. m.	11:40 a. m.	0.02	0.10	0.14	0.24	0.37	0.47	0.55	0.57							
Cairo, Ill.	27-28			0.74														0.40			
Canton, N. Y.	22-23			1.06														0.77			
Charles City, Iowa	6	5:54 p. m.	9:40 p. m.	1.60	5:55 p. m.	6:23 p. m.	0.01	0.09	0.22	0.60	0.89	0.94	1.03								
	26	2:54 p. m.	10:00 p. m.	1.65	5:31 p. m.	5:49 p. m.	0.29	0.08	0.54	0.79	0.82										
Charleston, S. C.	15	4:22 p. m.	5:45 p. m.	1.42	4:22 p. m.	5:15 p. m.	0.00	0.06	0.08	0.19	0.42	0.50	0.52	0.94	1.23	1.27	1.34	1.40			
Charlotte, N. C.	15			0.31														0.27			
Chattanooga, Tenn.	28			0.63														0.47			
Cheyenne, Wyo.	10-11			0.75														0.20			
Chicago, Ill.	5	5:45 p. m.	7:58 p. m.	0.55	5:48 p. m.	6:08 p. m.	0.01	0.17	0.31	0.37	0.43										
Cincinnati, Ohio	6	3:33 p. m.	4:50 p. m.	0.79	4:18 p. m.	4:34 p. m.	0.03	0.12	0.45	0.67	0.75										
Cleveland, Ohio	7			0.47														0.31			
Columbia, Mo.	27	2:15 a. m.	D. N. a. m.	1.41	3:22 a. m.	4:22 a. m.	0.07	0.15	0.16	0.32	0.58	0.72	0.76	0.78	0.84	0.87	0.89	1.06			
Columbia, S. C.	29			1.26														0.67			
Columbus, Ohio	1			0.34														0.27			
Concord, N. H.	15			2.39														0.48			
Concordia, Kans.	7	11:43 a. m.	1:22 p. m.	1.58	11:52 a. m.	12:27 p. m.	0.01	0.08	0.19	0.42	0.85	1.02	1.25	1.44							
Corpus Christi, Tex.	12			0.57														0.53			
Davenport, Iowa	5	4:38 p. m.	7:15 p. m.	0.67	6:24 p. m.	6:37 p. m.	0.14	0.31	0.40	0.44											
Dayton, Ohio	5	3:03 p. m.	4:41 p. m.	1.85	3:44 p. m.	4:16 p. m.	0.04	0.21	0.59	0.87	1.21	1.75	1.79								
		4:57 p. m.	9:40 p. m.	1.66	7:16 p. m.	8:00 p. m.	0.65	0.20	0.24	0.32	0.52	0.64	0.74	0.81	0.90	0.96					
Del Rio, Tex.	12	10:30 a. m.	4:25 p. m.	1.77	11:18 a. m.	11:32 a. m.	0.11	0.10	0.32	0.51											
					12:14 p. m.	12:46 p. m.	0.88	0.05	0.15	0.29	0.39	0.53	0.60	0.64							
Denver, Colo.	10-11			0.68														0.19			
Des Moines, Iowa	26			0.42														0.33			
Detroit, Mich.	7	8:07 p. m.	8:26 p. m.	0.61	8:07 p. m.	8:19 p. m.	0.00	0.16	0.54	0.61											
	27	6:15 p. m.	10:42 p. m.	1.06	6:20 p. m.	6:27 p. m.	0.02	0.25	0.29												
Devils Lake, N. Dak.	25			0.22														0.20			
Dodge City, Kans.	10-11			0.71														0.20			
Dubuque, Iowa	4	D. N. a. m.	8:35 a. m.	2.02	5:07 a. m.	5:41 a. m.	0.08	0.15	0.34	0.64	0.78	0.94	1.00	1.06							
					7:51 a. m.	8:14 a. m.	1.32	0.16	0.35	0.48	0.61	0.66									
	5	11:31 a. m.	12:02 p. m.	0.63	11:45 a. m.	11:57 a. m.	0.08	0.13	0.46	0.53											
	†5	12:27 p. m.	1:08 p. m.	0.82	12:35 p. m.	1:05 p. m.	0.01	0.05	0.11	0.16	0.27	0.66	0.81								
	11-12	9:46 p. m.	D. N. a. m.	0.74	9:49 p. m.	10:32 p. m.	0.01	0.18	0.25	0.27	0.36	0.43	0.46	0.54	0.62	0.66					
Duluth, Minn.	5	6:00 a. m.	11:55 p. m.	0.79	11:06 a. m.	11:27 a. m.	0.05	0.19	0.42	0.61	0.69	0.72									
Eastport, Me.	16			1.06														0.25			
Elkins, W. Va.	8	8:00 p. m.	10:00 p. m.	0.56	9:08 p. m.	9:36 p. m.	0.06	0.09	0.21	0.33	0.40	0.44	0.49								
El Paso, Tex.	1			0.42														0.37			
Erie, Pa.	7	6:38 p. m.	8:05 p. m.	1.10	6:40 p. m.	7:30 p. m.	0.01	0.08	0.19	0.25	0.39	0.42	0.42	0.45	0.81	0.98	1.08				
	7-8	10:10 p. m.	11:15 a. m.	1.32	5:23 a. m.	5:38 a. m.	0.62	0.28	0.38	0.48											
Escanaba, Mich.	4	9:50 a. m.	1:20 p. m.	1.09	11:22 a. m.	11:40 a. m.	0.22	0.10	0.24	0.36	0.46										
Eureka, Cal.	2			0.13														0.06			
Evansville, Ind.	1	3:40 p. m.	6:00 p. m.	1.96	3:42 p. m.	3:49 p. m.	0.01	0.31	0.33												
					4:53 p. m.	5:25 p. m.	0.58	0.15	0.37	0.65	0.83	1.06	1.31	1.36							
Flagstaff, Ariz.	8-9			1.06														*			
Fort Smith, Ark.	7	2:57 p. m.	5:16 p. m.	1.38	3:41 p. m.	4:22 p. m.	0.13	0.06	0.15	0.20	0.41	0.54	0.75	0.91	1.09	1.15					
	27	8:23 p. m.	10:10 p. m.	0.69	8:31 p. m.	8:47 p. m.	0.06	0.22	0.44	0.59	0.62										
Fort Wayne, Ind.	5-6	8:40 p. m.	D. N. a. m.	0.92	9:36 p. m.	9:56 p. m.	0.01	0.15	0.45	0.58	0.63										
Fort Worth, Tex.	24-25			0.62														0.36			
Fresno, Cal.	30-1[2]			0.31														0.09			
Galveston, Tex.	12-13	11:35 p. m.	D. N. a. m.	0.68	11:39 p. m.	11:55 p. m.	0.01	0.25	0.52	0.62	0.64										
	24	12:50 p. m.	3.15 p. m.	1.85	1:49 p. m.	2:25 p. m.	0.33	0.13	0.27	0.58	0.71	0.91	1.27	1.41	1.43						
Grand Haven, Mich.	4-5	7:39 p. m.	D. N. a. m.	1.82	7:40 p. m.	8:25 p. m.	T.	0.14	0.36	0.52	0.74	0.95	1.17	1.32	1.39	1.47					
Grand Junction, Colo.	8-9			0.28														0.17			
Grand Rapids, Mich.	4	8:12 p. m.	9:45 p. m.	0.63	8:15 p. m.	8:31 p. m.	0.01	0.14	0.34	0.47	0.50										
Green Bay, Wis.	26	10:24 a. m.	10:50 a. m.	0.33	10:29 a. m.	10:39 a. m.	0.02	0.15	0.31												
Hannibal, Mo.	27			1.74														0.44			
Harrisburg, Pa.	14-15	8:20 p. m.	7:50 a. m.	4.90														*			
Hartford, Conn.	15	12:20 p. m.	1:22 p. m.	1.06	12:34 p. m.	1:08 p. m.	0.04	0.15	0.35	0.44	0.58	0.73	0.89	1.01							
Hatteras, N. C.	5-6			2.04														*			
Havre, Mont.	2			0.18														0.18			
Helena, Mont.	3	6:07 a. m.	12:15 p. m.	0.86	6:18 a. m.	6:32 a. m.	0.04	0.21	0.40	0.48											
Houghton, Mich.	3-4	9:05 p. m.	9:40 a. m.	2.04	4:14 a. m.	4:36 a. m.	0.59	0.23	0.33	0.37	0.47	0.51									
Houston, Tex.	13	3:18 p. m.	10:20 p. m.	1.29	5:10 p. m.	5:24 p. m.	0.62	0.17	0.29	0.36											
	24	11:42 a. m.	12:15 p. m.	0.58	11:48 a. m.	12:06 p. m.	0.01	0.16	0.38	0.50	0.57										
Huron, S. Dak.	6	8:05 p. m.	D. N. p. m.	0.71	8:13 p. m.	8:27 p. m.	0.03	0.19	0.40	0.48											
Independence, Cal.	30			0.07														0.03			
Indianapolis, Ind.	6	7:07 p. m.	9:15 p. m.	0.69	7:12 p. m.	7:39 p. m.	0.01	0.09	0.14	0.22	0.38	0.54	0.56								
	27	7:07 p. m.	11:15 p. m.	1.02	7:38 p. m.	8:28 p. m.	0.02	0.13	0.26	0.35	0.39	0.42	0.50	0.60	0.61	0.70	0.80				
Iola, Kans.	11	6:26 p. m.	8:04 p. m.	1.20	7:13 p. m.	7:37 p. m.	0.02	0.51	0.76	0.95	1.10	1.16									
	11	8:25 p. m.	9:28 p. m.	1.81	8:27 p. m.	9:14 p. m.	0.01	0.19	0.45	0.79	1.02	1.08	1.12	1.31	1.47	1.70	1.80				
	11-12	10:45 p. m.	D. N. a. m.	1.42	11:39 p. m.	12:30 a. m.	0.22	0.14	0.23	0.27	0.36	0.60	0.68	0.72	0.85	0.91	1.14	1.19			
Jacksonville, Fla.	8	12:13 p. m.	3:12 p. m.	0.64	1:15 p. m.	1:24 p. m.	0.15	0.21	0.39												
	9	2:00 p. m.	4:00 p. m.	0.82	2:12 p. m.	2:24 p. m.	0.01	0.21	0.57	0.71											
	12	2:20 p. m.	9:30 p. m.	1.99	6:03 p. m.	7:30 p. m.	0.31	0.10	0.21	0.32	0.37	0.42	0.62	0.63	0.63	0.63	0.82	0.88	1.32	1.46	
	17	D. N. a. m.	D. N. a. m.	0.65	2:11 a. m.	2:27 a. m.	0.12	0.15	0.31	0.45	0.47										
Kalispell, Mont.	9			0.29														0.19			
Kansas City, Mo.	26-27	10:05 p. m.	3:20 a. m.	1.49	1:33 a. m.	2:04 a. m.	0.17	0.05	0.13	0.26	0.50	0.65	0.76	0.79							
					2:40 a. m.	3:00 a. m.	0.98	0.09	0.25	0.40	0.50										

[1] August 31. [2] October 1. * Self-register not working. † Record partly estimated. ‡ No precipitation during the month.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any five minutes, or 0.80 in 1 hour, during September, 1916, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Keokuk, Iowa	11	6:30 p.m.	8:10 p.m.	1.23	6:43 p.m.	7:27 p.m.	0.01	0.10	0.21	0.25	0.32	0.40	0.65	0.82	1.01	1.10					
Key West, Fla	4	5:40 p.m.	7:05 p.m.	0.78	6:13 p.m.	6:30 p.m.	0.02	0.17	0.48	0.70	0.74										
	7	11:05 a.m.	12:15 p.m.	0.52	11:39 a.m.	12:04 p.m.	0.01	0.07	0.09	0.16	0.31	0.51									
	15	D. N. p.m.	D. N. p.m.	0.59	10:27 p.m.	10:43 p.m.	0.01	0.22	0.40	0.49	0.55										
	17	D. N. p.m.	D. N. p.m.	0.64	11:16 p.m.	11:37 p.m.	0.01	0.21	0.40	0.52	0.58	0.61									
Knoxville, Tenn	18	12:08 p.m.	12:35 p.m.	0.55	12:13 p.m.	12:29 p.m.	0.01	0.14	0.39	0.50	0.54										
La Crosse, Wis	6	6:36 p.m.	D. N. p.m.	0.79	6:41 p.m.	6:55 p.m.	0.01	0.26	0.37	0.46											
	26	3:45 p.m.	9:35 p.m.	2.01	5:26 p.m.	5:51 p.m.	0.04	0.23	0.43	0.63	0.93	1.15									
Lander, Wyo	9			0.04														0.04			
Lansing, Mich	27			1.34														0.44			
Lewiston, Idaho	7–8			0.21														0.08			
Lexington, Ky	14			0.40														0.33			
Lincoln, Nebr	5			0.44														0.29			
Little Rock, Ark	21	4:45 p.m.	6:50 p.m.	0.47	6:17 p.m.	6.30 p.m.	0.09	0.20	0.29	0.38											
Los Angeles, Cal	30			0.77														0.56			
Louisville, Ky	1–2	1:41 p.m.	D. N. a.m.	2.38	1:31 a.m.	2:37 a.m.	1.12	0.06	0.16	0.26	0.37	0.45	0.51	0.64	0.74	0.77	0.84	1.05	1.21		
Ludington, Mich	27			0.89														0.27			
Lynchburg, Va	8	3:55 p.m.	4:25 p.m.	0.36	4:14 p.m.	4:23 p.m.	0.01	0.29	0.35												
Macon, Ga	3	3:11 p.m.	4:06 p.m.	0.39	3:14 p.m.	3:24 p.m.	0.01	0.18	0.33												
	14–15	D. N. p.m.	D. N. a.m.	1.03	11:36 p.m.	12:00 p.m.	0.30	0.17	0.28	0.39	0.58	0.66									
Madison, Wis	5	12:38 p.m.	2:55 p.m.	0.94	12:50 p.m.	1:10 p.m.	0.01	0.20	0.42	0.64	0.75										
	6–7	10:45 p.m.	D. N. a.m.	1.73	10:58 p.m.	11:33 p.m.	0.02	0.20	0.35	0.43	0.49	0.58	0.64	0.72							
					12:21 a.m.	12:38 a.m.	0.90	0.15	0.23	0.29	0.46										
Marquette, Mich	6–7	6:04 p.m.	6:00 a.m.	2.43	6:39 p.m.	7:09 p.m.	0.04	0.45	0.74	0.96	1.10	1.21	1.27								
					8:24 p.m.	8:42 p.m.	1.47	0.18	0.28	0.35	0.41										
Memphis, Tenn	22			0.73														0.32			
Meridian, Miss	†8	3:40 p.m.	6:05 p.m.	0.68	3:48 p.m.	4:17 p.m.	0.03	0.07	0.19	0.31	0.41	0.49	0.54								
Miami, Fla	15	11:41 a.m.	11:50 a.m.	0.28	11:43 a.m.	11:48 a.m.	0.01	0.25													
	19	1:55 p.m.	6:35 p.m.	0.86	2:07 p.m.	2:26 p.m.	0.01	0.09	0.26	0.40	0.51										
	30	3:15 p.m.	6:45 p.m.	0.92	3:22 p.m.	3:46 p.m.	0.01	0.16	0.31	0.65	0.81	0.87									
Milwaukee, Wis	6–7	11:55 p.m.	7:20 a.m.	2.61	2:31 a.m.	3:11 a.m.	0.64	0.22	0.48	0.56	0.60	0.66	0.72	0.83	0.95						
					5:35 a.m.	5:45 a.m.	1.98	0.24	0.41												
Minneapolis, Minn	12			0.70														0.27			
Mobile, Ala	2–3	8:03 p.m.	D. N. a.m.	2.96	8:12 p.m.	8:48 p.m.	0.01	0.10	0.24	0.33	0.49	0.65	0.83	0.90	0.93						
					10:16 p.m.	10:44 p.m.	0.97	0.28	0.68	1.23	1.57	1.82	1.90								
	10–11	11:40 a.m.	D. N. a.m.	1.08	12:55 p.m.	1:27 p.m.	0.03	0.22	0.40	0.49	0.56	0.64	0.69	0.71							
	28	D. N. a.m.	8:30 a.m.	1.24	5:11 a.m.	5:37 a.m.	0.27	0.05	0.11	0.19	0.35	0.45	0.49								
					7:54 a.m.	8:06 a.m.	0.87	0.24	0.30	0.34											
Modena, Utah	30			0.56														0.30			
Montgomery, Ala	2	4:00 p.m.	5:20 p.m.	0.65	4:17 p.m.	4:42 p.m.	0.09	0.07	0.20	0.37	0.44	0.55									
Moorhead, Minn	9–10			1.16														0.48			
Mount Tamalpais, Cal	21–22			0.68														0.31			
Nantucket, Mass	30			0.54														0.30			
Nashville, Tenn	14	10:15 a.m.	10:40 a.m.	0.40	10:15 a.m.	10:26 a.m.	0.00	0.15	0.38	0.40											
New Haven, Conn	29			0.94														0.33			
New Orleans, La	4	3:16 p.m.	4:20 p.m.	0.66	3:16 p.m.	3:35 p.m.	0.00	0.22	0.40	0.59	0.64										
	5	8:50 a.m.	9:35 a.m.	0.51	9:06 a.m.	9:20 a.m.	0.08	0.11	0.30	0.41											
	11	11:05 p.m.	12:40 p.m.	1.03	11:37 a.m.	12:20 p.m.	0.11	0.12	0.20	0.21	0.25	0.36	0.47	0.62	0.47	0.82					
New York, N. Y	29	3:42 p.m.	9:25 p.m.	0.76	3:47 p.m.	4:02 p.m.	T.	0.22	0.36	0.47											
Norfolk, Va	5–6	10:15 p.m.	6:30 a.m.	0.88	1:30 a.m.	1:46 a.m.	0.18	0.13	0.29	0.41	0.44										
	29	2:40 p.m.	4:45 p.m.	0.76	2:52 p.m.	3:21 p.m.	0.01	0.12	0.27	0.31	0.48	0.58	0.65								
Northfield, Vt	15			1.08														0.60			
North Head, Wash	7–8			0.45														0.16			
North Platte, Nebr	9			0.46														0.40			
Oklahoma, Okla	7	8:35 p.m.	9:05 p.m.	0.55	8:40 p.m.	8:54 p.m.	0.02	0.14	0.33	0.51											
Omaha, Nebr	10–11			1.18														0.36			
Oswego, N. Y	2			0.29														0.24			
Palestine, Tex	8	2:10 p.m.	3:20 p.m.	1.44	2:15 p.m.	3:03 p.m.	0.01	0.21	0.39	0.50	0.65	0.78	0.95	1.10	1.22	1.36	1.40				
	13	1:00 p.m.	7:20 p.m.	1.15	1:07 p.m.	1:35 p.m.	0.01	0.17	0.35	0.61	0.83	0.96	1.04								
Parkersburg, W. Va	7	3:40 a.m.	5:50 a.m.	0.78	4:52 a.m.	5:22 a.m.	0.06	0.13	0.24	0.29	0.45	0.55	0.68								
	14	3:34 p.m.	4:01 p.m.	0.48	3:37 p.m.	3:47 p.m.	0.01	0.29	0.45												
	28	4:12 p.m.	7:10 p.m.	0.72	4:38 p.m.	4:52 p.m.	0.01	0.28	0.57	0.62											
Pensacola, Fla	2	9:25 p.m.	10:40 p.m.	0.80	9:47 p.m.	10:06 p.m.	0.02	0.09	0.33	0.51	0.67										
Peoria, Ill	5–6	8:17 p.m.	5:00 a.m.	1.35	8:37 p.m.	9:05 p.m.	0.01	0.33	0.45	0.52	0.70	0.79	0.84								
	12	3:43 p.m.	5:30 p.m.	0.85	3:51 p.m.	4:15 p.m.	0.03	0.15	0.33	0.49	0.50	0.59									
Philadelphia, Pa	8	1:58 p.m.	4:00 p.m.	1.44	2:53 p.m.	3:40 p.m.	0.30	0.20	0.24	0.39	0.46	0.54	0.72	0.89	1.02	1.08	1.11				
Phoenix, Ariz	9	12:40 p.m.	1:20 p.m.	0.47	12:58 p.m.	1:10 p.m.	0.02	0.09	0.38	0.44											
Pierre, S. Dak	6	5:55 p.m.	6:58 p.m.	0.64	6:01 p.m.	6:13 p.m.	T.	0.25	0.45	0.53											
Pittsburgh, Pa	28–29			0.58														0.30			
Pocatello, Idaho	22			0.01														0.01			
Point Reyes Light, Cal	30	10:30 a.m.	7:30 p.m.	1.59	2:55 p.m.	3:52 p.m.	0.18	0.10	0.18	0.28	0.40	0.47	0.50	0.52	0.56	0.64	0.72	0.82			
Port Huron, Mich	21			0.24														0.21			
Portland, Me	15–16			0.65														0.33			
Portland, Oreg	2			0.19														0.16			
Providence, R. I	15–16			0.38														0.15			
Pueblo, Colo	5			T.														T.			
Raleigh, N. C	15	2:05 p.m.	3:00 p.m.	0.58	2:11 p.m.	2:18 p.m.	0.02	0.33	0.40												
Rapid City, S. Dak	6			0.02														0.02			
Reading, Pa	15			1.08														0.40			
Red Bluff, Cal	30			0.06														0.03			
Reno, Nev	21–22			0.33														0.07			
Richmond, Va	7			0.34														0.34			
Rochester, N. Y	7			0.26														0.21			
Roseburg, Oreg	2–3			0.38														0.20			
Roswell, N. Mex	12			0.30														0.24			
Sacramento, Cal	21			0.15														0.11			
Saginaw, Mich	27			0.66														0.31			
St. Joseph, Mo	11–12	5:40 p.m.	D. N. a.m.	1.13	1:27 a.m.	1:48 a.m.	0.15	0.28	0.45	0.51	0.59	0.62									
St. Louis, Mo	7	1:57 p.m.	7:24 p.m.	0.88	1:57 p.m.	2:23 p.m.	0.00	0.18	0.28	0.37	0.53	0.59	0.63								
	27	4:08 p.m.	7:45 p.m.	1.11	4:27 p.m.	4:37 p.m.	0.02	0.28	0.81												
St. Paul, Minn	6			0.66														0.20			
Salt Lake City, Utah	22			0.43														0.30			
San Antonio, Tex	12	3:50 p.m.	7:50 p.m.	1.00	4:00 p.m.	4:32 p.m.	0.01	0.17	0.34	0.46	0.59	0.65	0.71	0.74							
	25	2:31 a.m.	5:18 a.m.	2.20	2:56 a.m.	3:14 a.m.	0.04	0.15	0.30	0.41	0.44										
					3:57 a.m.	4:55 a.m.	0.66	0.15	0.36	0.64	0.78	0.90	1.01	1.12	1.23	1.32	1.40	1.52			
San Diego, Cal	30			0.25														0.13			
Sand Key, Fla	7			0.84														0.39			
Sandusky, Ohio	27–28			0.98														0.46			
San Francisco, Cal	30			0.72														0.25			

* Self-register not working. † Record partly estimated. ‡ No precipitation during the month.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during September, 1916, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
San Jose, Cal	21			0.60														0.25			
San Luis Obispo, Cal	29–30			1.66														0.41			
Santa Fe, N. Mex	5	7:10 p.m.	10:15 p.m.	0.56	8:28 p.m.	8:42 p.m.	0.04	0.22	0.38	0.44											
Sault Ste. Marie, Mich	3–4	7:30 p.m.	5:20 p.m.	5.39	1:15 a.m.	1:34 a.m.	0.15	0.08	0.29	0.40	0.49										
					7:06 a.m.	8:03 a.m.	1.63	0.12	0.14	0.32	0.39	0.49	0.51	0.55	0.60	0.77	0.90	1.09			
					8:38 a.m.	8:56 a.m.	2.87	0.12	0.33	0.42	0.46										
					10:18 a.m.	11:03 a.m.	4.04	0.15	0.22	0.30	0.41	0.48	0.52	0.64	0.79	0.86					
	26–27	5:27 p.m.	D. N. a.m.	0.76	10:22 p.m.	10:27 p.m.	0.33	0.25													
Savannah, Ga	13–14			1.03														0.34			
Scranton, Pa	14–15	10:40 p.m.	9:31 a.m.	2.34	11:43 p.m.	11:59 p.m.	0.15	0.12	0.34	0.52	0.57										
Seattle, Wash	8			0.53														0.34			
Sheridan, Wyo	9–10			0.48														0.27			
Shreveport, La	12			0.89														0.78			
Sioux City, Iowa	9–10	6:30 p.m.	4:35 a.m.	1.86	12:41 a.m.	1:02 a.m.	1.00	0.20	0.28	0.37	0.54	0.58									
Spokane, Wash	23			0.21														0.09			
Springfield, Ill	27			2.18														0.55			
Springfield, Mo	1–2			0.53														0.23			
Syracuse, N. Y	14–15			1.47														0.42			
Tacoma, Wash	2			0.46														0.35			
Tampa, Fla	4	2:15 p.m.	3:16 p.m.	0.42	2.24 p.m.	2:37 p.m.	0.01	0.14	0.31	0.35											
	8	2:14 p.m.	2:33 p.m.	0.36	2:18 p.m.	2:26 p.m.	0.01	0.31	0.34												
	8	3:39 p.m.	5:20 p.m.	1.15	3:41 p.m.	3:49 p.m.	0.02	0.29	0.36												
					4:41 p.m.	4:55 p.m.	0.39	0.36	0.63	0.76											
	17	3:30 p.m.	4:30 p.m.	0.84	3:33 p.m.	4:12 p.m.	0.01	0.17	0.22	0.36	0.42	0.45	0.58	0.69	0.76						
Tatoosh Island, Wash	7			0.39														0.21			
Taylor, Tex	25			0.33														0.28			
Terre Haute, Ind	1			0.41														0.39			
Thomasville, Ga	9	1:20 p.m.	5:25 p.m.	1.00	1:27 p.m.	2:00 p.m.	0.01	0.13	0.32	0.46	0.52	0.63	0.71	0.77							
	10	12:52 p.m.	3:20 p.m.	0.52	1:40 p.m.	1:54 p.m.	0.07	0.24	0.36	0.44											
Toledo, Ohio	26			1.03														0.42			
Tonopah, Nev	22			0.13														0.06			
Topeka, Kans	11	7:08 a.m.	10:05 a.m.	0.55	8:46 a.m.	9:08 a.m.	0.02	0.08	0.15	0.28	0.42	0.47									
Valentine, Nebr	5–6			0.22														0.14			
Vicksburg, Miss	11	11:18 a.m.	3:50 p.m.	1.77	12:26 p.m.	1:26 p.m.	0.03	0.06	0.19	0.30	0.45	0.60	0.91	1.12	1.26	1.35	1.41	1.55			
	25	6:51 p.m.	10:30 p.m.	1.80	6:53 p.m.	7:14 p.m.	0.01	0.33	0.65	0.93	1.32	1.39									
Walla Walla, Wash	9			0.05														0.05			
Washington, D. C	15	11:06 a.m.	2:10 p.m.	1.17	11:13 a.m.	11:38 a.m.	0.01	0.29	0.48	0.67	0.80	0.87									
Wichita, Kans	3			0.48														0.17			
Williston, N. Dak	24			0.20														0.17			
Wilmington, N. C	5	D. N. a.m.	4.10 p.m.	2.41	2:05 p.m.	3:33 p.m.	0.76	0.05	0.12	0.21	0.33	0.47	0.58	0.65	0.77	0.85	0.92	1.08	1.39	1.65	
Winnemucca, Nev	22			0.26														0.07			
Wytheville, Va	28–29	9:05 p.m.	5:55 a.m.	1.33	9:54 p.m.	10:14 p.m.	0.31	0.16	0.27	0.37	0.47										
Yankton, S. Dak	10	12:15 a.m.	3:30 a.m.	0.77	12:36 a.m.	1:02 a.m.	0.10	0.13	0.32	0.39	0.44	0.58	0.60								
Yellowstone Park, Wyo	26–27			0.36														*			

* Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, September, 1916.*

Stations.	Altitude above M. S. L.* Jan. 1, 1916.	Pressure. Station, reduced to mean of 24 hours.	Pressure. Sea-level, reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature of the air. Mean max. + mean min. ÷ 2.	Temperature of the air. Departure from normal.	Temperature of the air. Mean maximum.	Temperature of the air. Mean minimum.	Temperature of the air. Highest.	Temperature of the air. Lowest.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F	125	29.73	29.86	−0.11	54.6	+0.6	61.3	47.8	76	37	2.52	−1.19	0
Sydney, C. B. I	48	29.96	*30.00*	*− .01*	59.6	+3.1	69.5	49.6	83	38	2.78	−0.50	0
Halifax, N. S	88	29.91	*30.01*	*− .03*	59.1	+1.5	69.7	48.4	81	38	2.70	−1.01	0
Yarmouth, N. S	65	29.95	30.02	− .03	56.6	+0.5	64.2	49.0	76	37	2.29	−1.16	0
Charlottetown, P. E. I	38	29.94	29.98	− .03	59.0	+1.7	66.9	51.2	79	40	1.64	−1.76	0
Chatham, N. B	28	29.95	*29.97*	*− .03*	58.2	+2.8	68.1	48.3	84	35	2.32	−0.39	0
Father Point, Que	20	29.92	29.94	− .04	51.4	+1.0	59.6	43.2	77	36	3.65	+0.52	0
Quebec, Que	296	29.66	29.98	− .03	56.4	+1.3	64.0	48.8	76	37	5.12	+1.45	0
Montreal, Que	187	29.78	29.98	− .06	59.3	+0.9	67.4	51.2	80	40	4.05	+0.75	0
Stonecliffe, Ont	489	29.36	*29.96*	*− .07*	56.0	+0.3	66.2	45.9	82	31	3.03	−0.25	0
Ottawa, Ont	236	29.72	*30.04*	*.00*	58.9	+1.5	67.7	50.1	83	36	3.06	+0.37	0
Kingston, Ont	285	29.70	30.01	− .03	60.9	+0.9	68.7	53.2	80	33	2.92	+0.12	0
Toronto, Ont	379	29.60	*29.97*	*− .09*	61.2	+2.2	71.2	51.1	90	35	1.66	−1.59	0
White River, Ont	1,244	28.52	*29.91*	*− .07*	47.8	−2.5	59.0	36.6	74	18	2.35	−0.42	0.5
Port Stanley, Ont	592	29.39	30.03	− .03	59.6	+0.1	67.7	51.6	79	32	2.42	−0.31	0
Southampton, Ont	656	29.30			59.8	+2.3	68.0	51.7	86	36	3.16	+0.22	0
Parry Sound, Ont	688	29.28	29.97	− .06	58.1	+2.1	67.1	49.2	84	28	4.82	+1.15	0
Port Arthur, Ont	644	29.21	29.92	− .06	51.9	−0.3	60.4	43.5	76	26	5.11	+1.63	0
Winnipeg, Man	760	29.04	29.87	− .07	53.6	+1.1	64.3	43.0	79	27	2.03	0.00	T.
Minnedosa, Man	1,690	28.06	29.85	− .09	51.8	+1.3	63.4	40.2	79	24	1.78	+0.42	0.5
Qu'Appelle, Sask	2,115	27.61	29.85	− .07	50.2	−0.9	62.9	37.5	80	24	5.39	+4.06	T.
Medicine Hat, Alberta	2,144	27.60	*29.87*	*− .05*	56.5	+1.5	70.5	42.4	84	29	1.11	−0.07	0
Swift Current, Sask	2,392	27.32	*29.87*	*− .05*	53.4	+0.3	66.9	39.9	81	25	1.46	+0.24	0
Calgary, Alberta	3,428	26.40	*29.91*	*− .01*	52.3	+2.5	65.8	38.8	80	23	0.84	−0.52	T.
Banff, Alberta	4,521	25.38	*29.95*	*+ .02*	47.7	+1.9	60.4	35.0	71	25	1.82	+0.15	2.3
Edmonton, Alberta	2,150	27.59	*29.87*	*− .03*	50.8	+1.5	62.3	39.3	79	29	2.83	+1.50	T.
Prince Albert, Sask	1,450	28.31	*29.86*	*− .04*	50.7	+2.3	63.4	37.9	80	26	1.00	−0.28	1.0
Battleford, Sask	1,592	28.13	*29.85*	*− .05*	52.0	+0.2	64.5	39.5	81	23	1.05	−0.20	0
Kamloops, B. C	1,262	28.74	30.02	+ .05	57.6	+0.2	70.1	45.1	81	33	0.36	−0.49	0
Victoria, B. C	230	29.79	30.04	+ .03	56.7	+1.9	64.4	48.9	80	43	0.35	−1.81	0
Barkerville, B. C	4,180	29.74	30.06	+ .08	44.1	−2.6	54.2	34.0	69	22	2.62	−0.29	4.5
Hamilton, Bermuda	151	29.91	30.07	.00	77.2	−0.2	82.9	71.5	87	68	6.98	+0.47	0

* The altitudes given above were furnished by the Director of the Canadian Meteorological Service, Mar. 9, 1916, and refer to cisterns of barometers at the respective stations. Where sea-level pressures and departures are *italicized* new reduction factors are in course of computation.—C. A., jr.

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Chart I. Hydrographs of Several Principal Rivers, September, 1916.

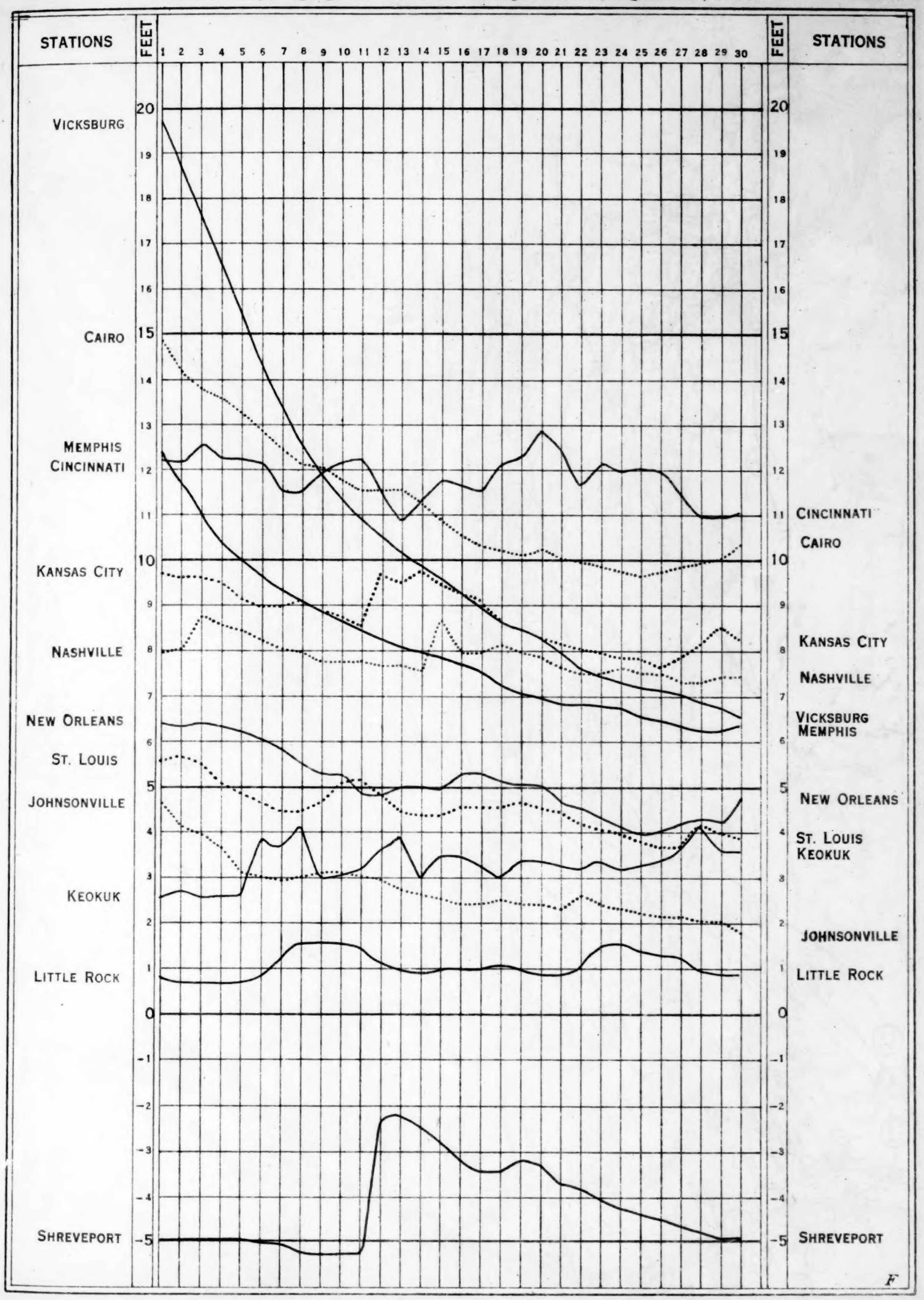


Chart II. Tracks of Centers of High Areas, September, 1916.

(Plotted by E. H. Bowie.)

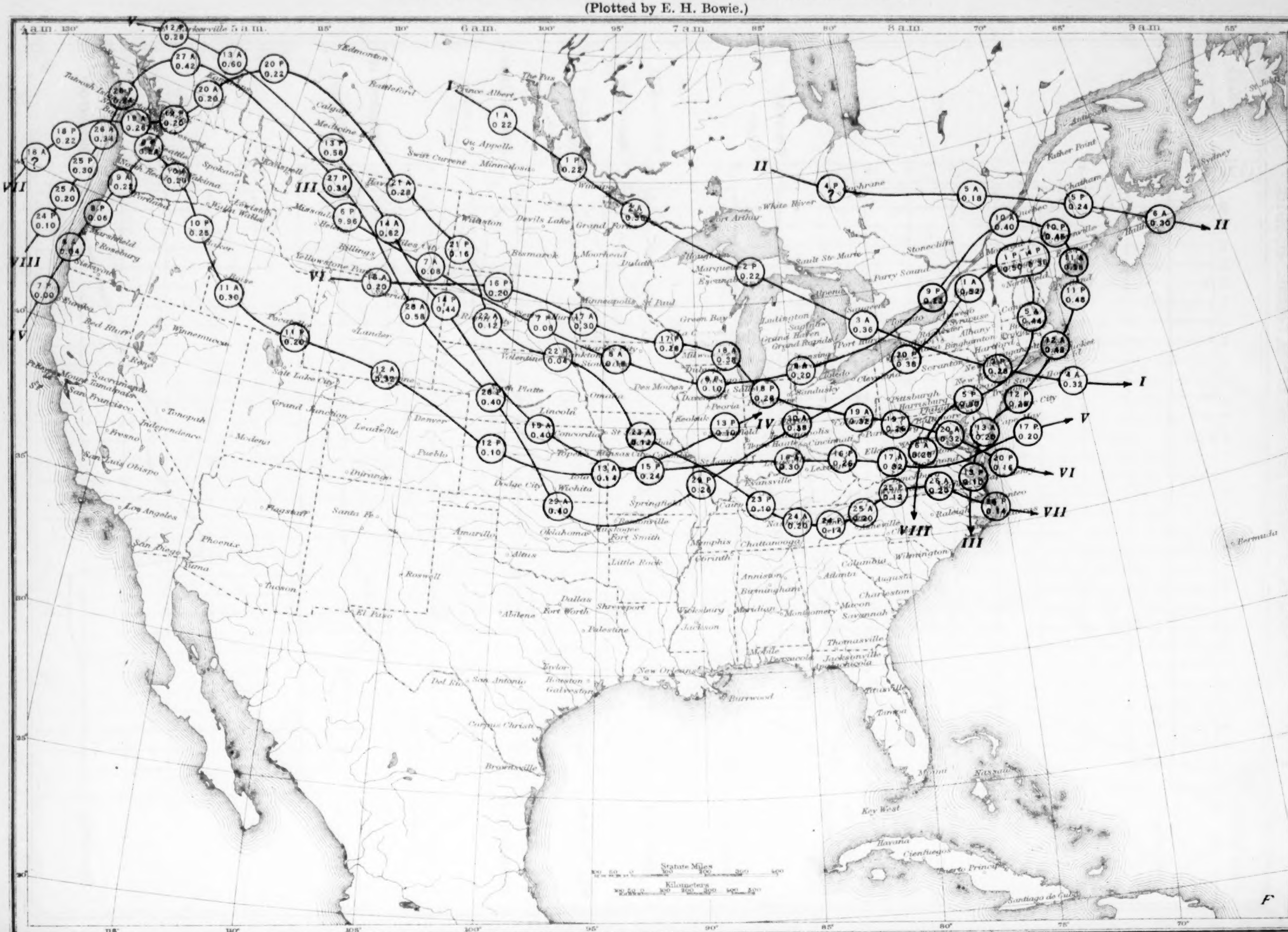


Chart III. Tracks of Centers of Low Areas, September, 1916.

(Plotted by E. H. Bowie.)

Chart III. Tracks of Centers of Low Areas, September, 1916.

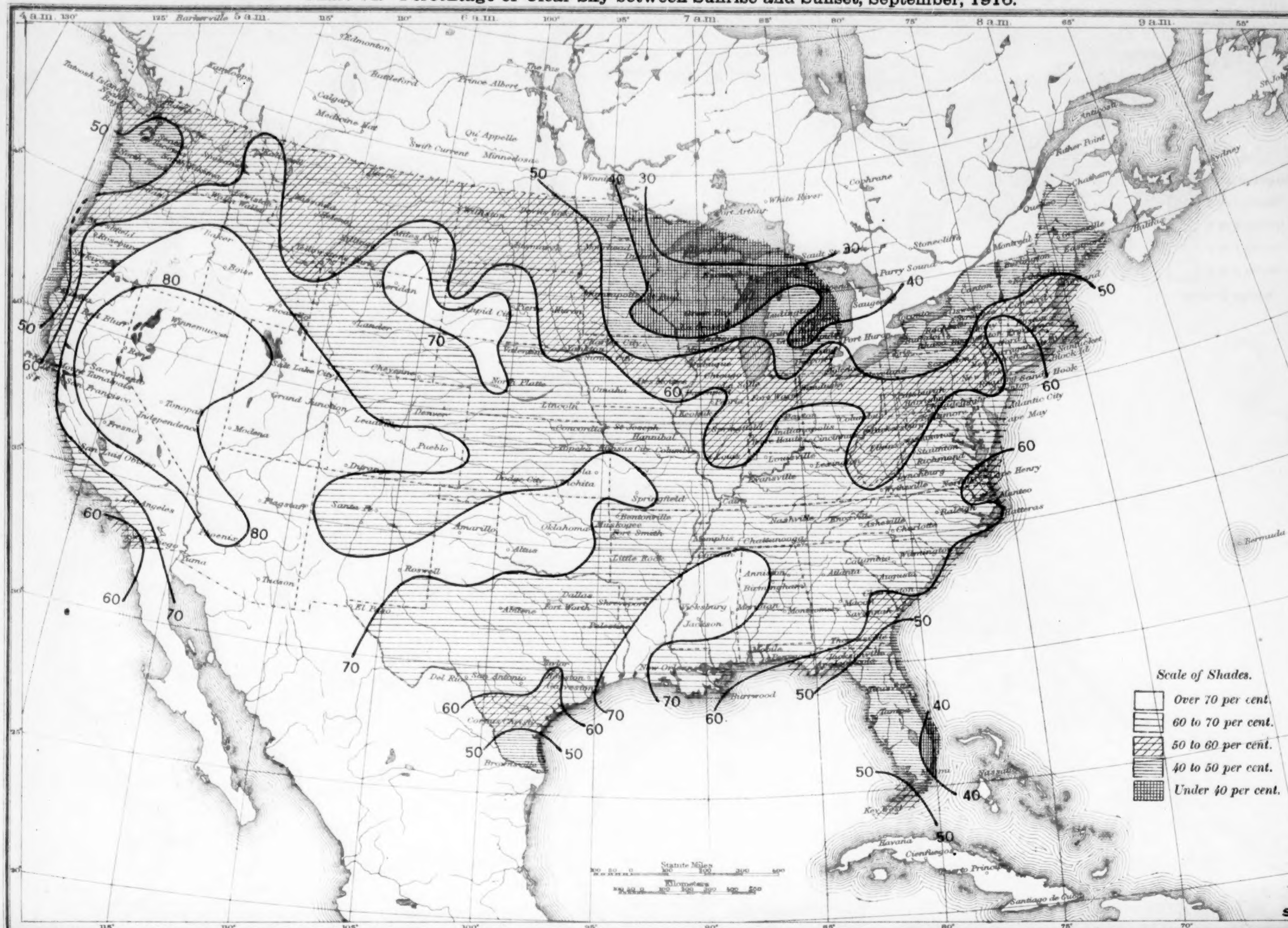
(Plotted by E. H. Bowie.)

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, September, 1916.

Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency.

Chart V. Total Precipitation, September, 1916.

Chart VI. Percentage of Clear Sky between Sunrise and Sunset, September, 1916.



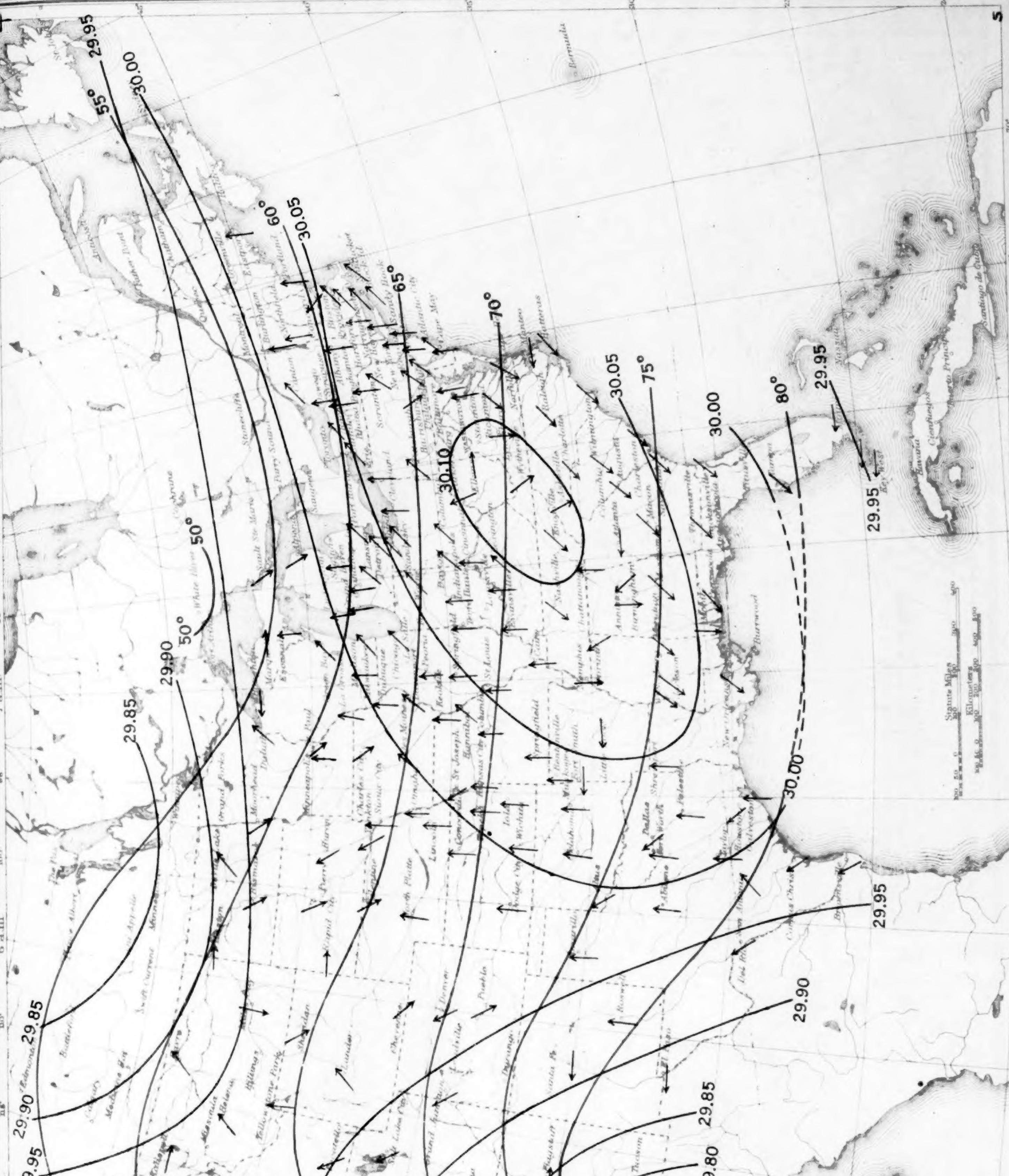


Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, September, 1916.

Chart IX. Means of Meteorological Data for North Atlantic Ocean, September, 1915.

(Plotted by F. A. Young.)

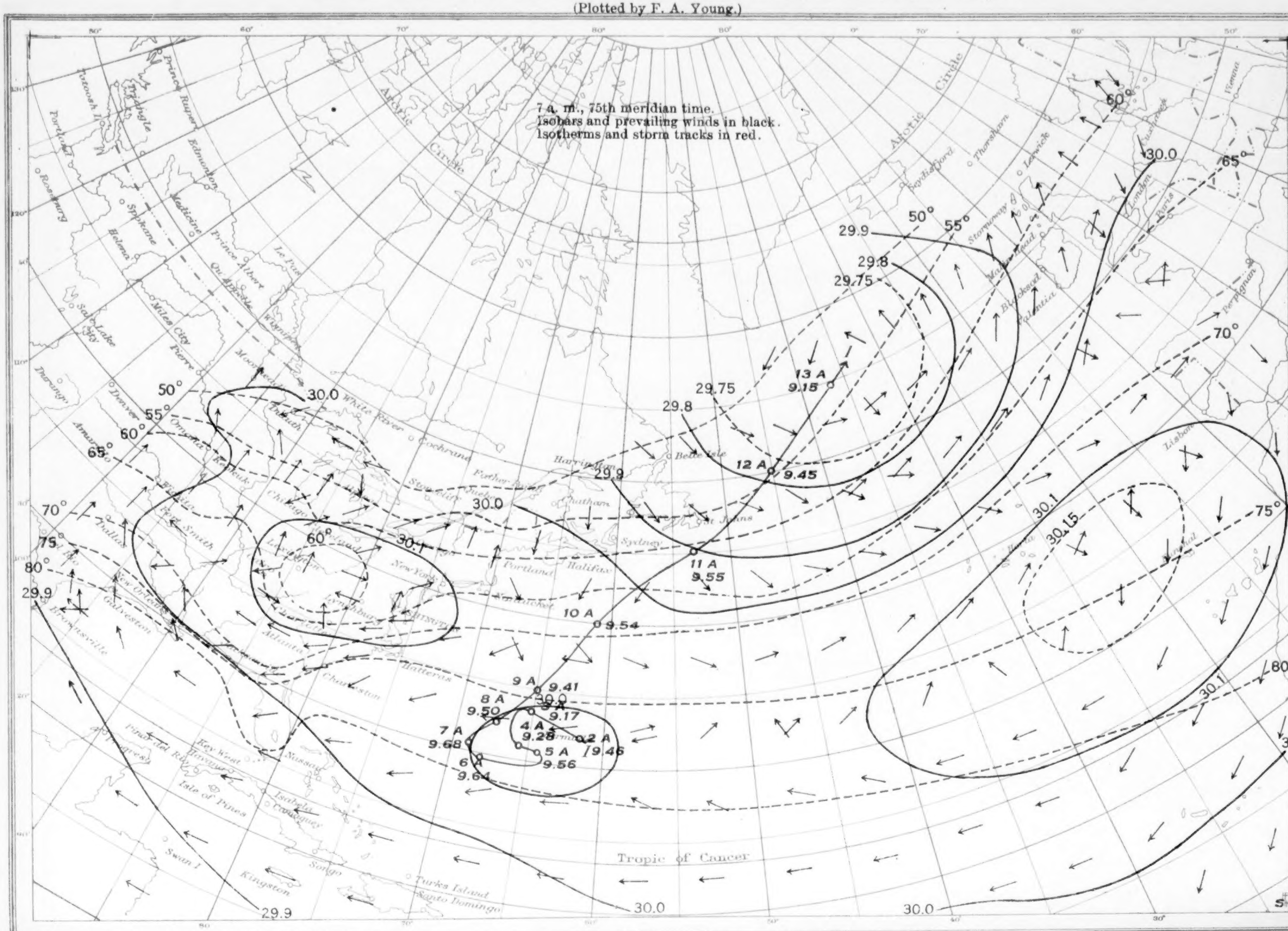
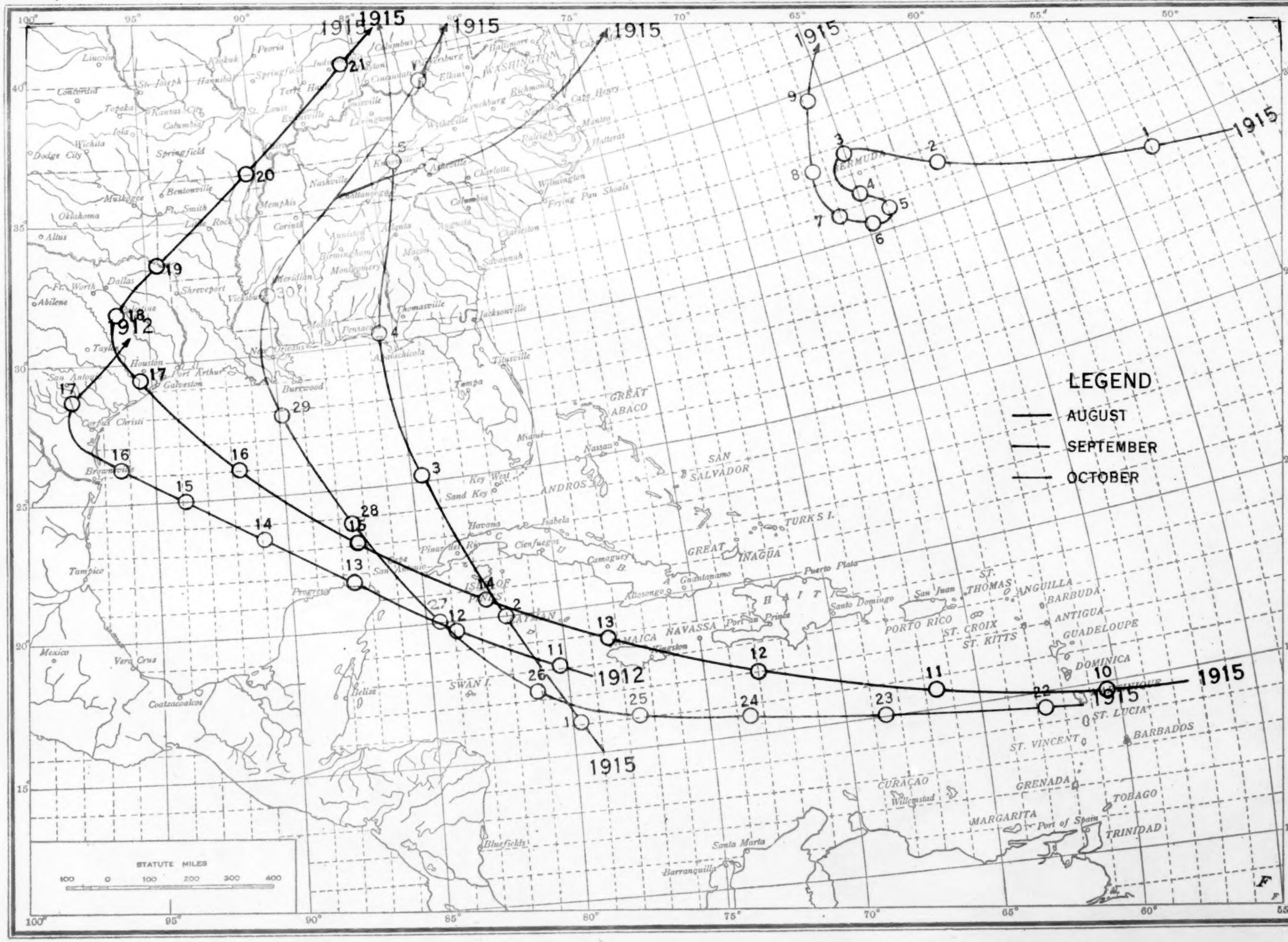
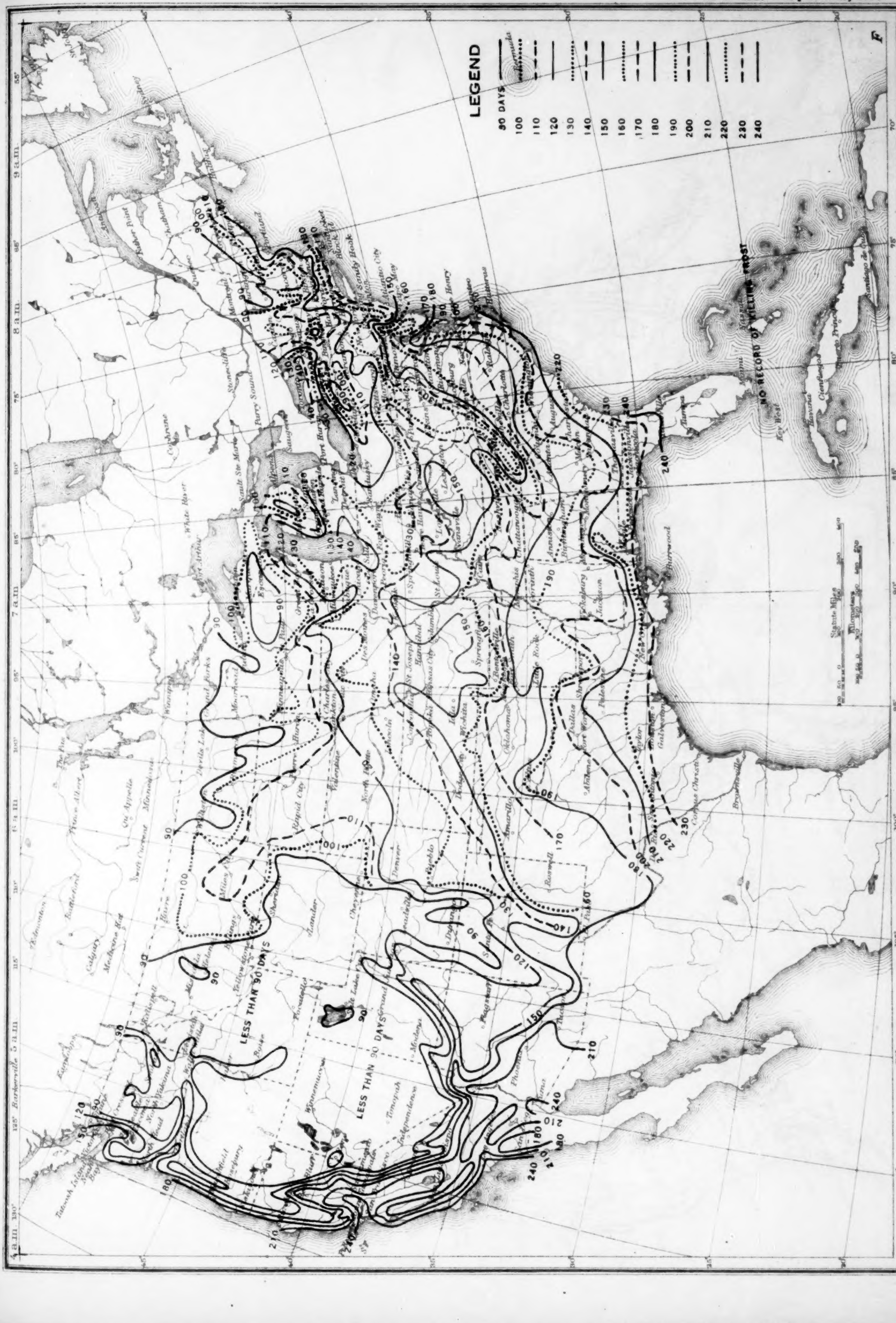


Chart X. Tracks of West Indian Hurricanes, 1912 to 1915, inclusive.

Chart X. Tracks of West Indian Hurricanes, 1912 to 1915, inclusive.

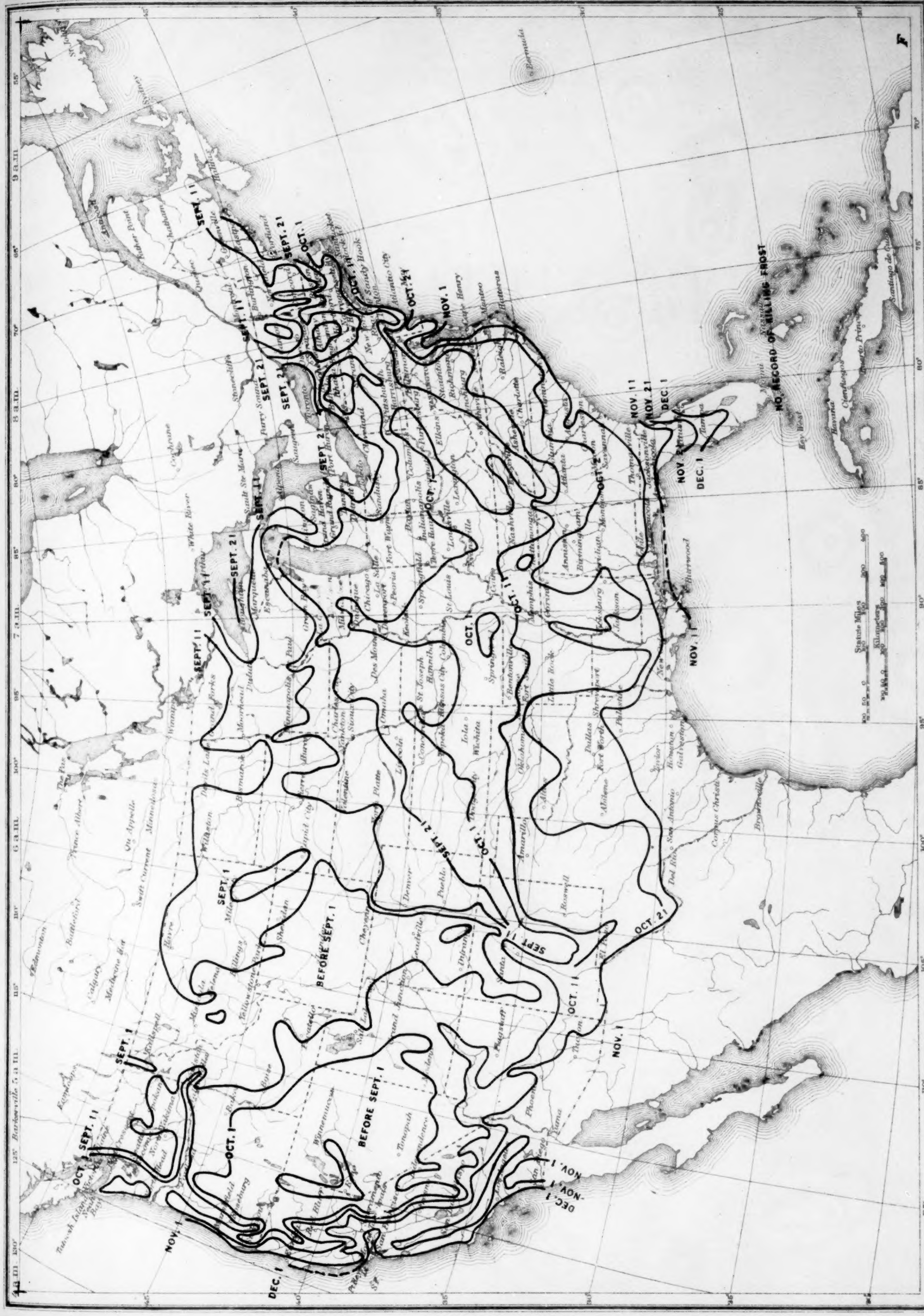
(Plotted by R. H. Weightman.)





W. G. R. Fig. 2.—The available growing season in the United States.

W. G. R. Fig. 3.—Dates when the chance of a killing frost in Spring falls to 10 per cent.



W. G. R. Fig. 4.—Dates when the chance of a killing frost in Fall rises to 10 per cent.

W. G. R. Fig. 3.—Dates when the chance of a killing frost in Spring falls to 10 per cent.